BUREAU OF ECONOMIC GEOLOGY
The University of Texas
Austin, Texas

Report of Investigations—No. 52

Stratigraphy of the Fredericksburg Division, South-Central Texas

By
Clyde H. Moore, Jr.

July 1964

BUREAU OF ECONOMIC GEOLOGY
The University of Texas
Austin, Texas

Report of Investigations—No. 52

Stratigraphy of the Fredericksburg Division, South-Central Texas

By
CLYDE H. MOORE, JR.

July 1964

Contents

Illustrations

Tables

Stratigraphy of the Fredericksburg Division, South-Central Texas

CLYDE H. MOORE, JR.[1]

ABSTRACT

Sediments of the Fredericksburg Division in south-central Texas were deposited on the slowly subsiding west flank of the Tyler basin. In this region there are three stratigraphically distinct areas. The southern area has a thick Edwards Limestone unit overlying a thin Walnut Formation. The intermediate area has a thinner Edwards sequence and Comanche Peak Limestone intervening between the Edwards and an expanded Walnut Formation. The Paluxy Sandstone occurs at the base of the Fredericksburg in the northern area, and there is further expansion of the Walnut Formation accompanied by an attenuated Edwards biohermal limestone characteristic of this formation in north-central Texas.

The Walnut Formation has six members, from bottom to top, the Bull Creek, Bee Cave, Cedar Park, Whitestone, Keys Valley, and an unnamed upper marl. The Cedar Park Limestone Member is emended to include only the nodular fossiliferous micrite below the oosparite and pelsparite occurring at the Cedar Park quarries in Williamson County. The oosparite and pelsparite are termed the Whitestone Limestone Member. A similar development in the vicinity of Moffat, Bell County, is referred to as the Moffat mound of the Edwards Formation.

The Edwards, Comanche Peak, and Walnut are gradational. The Walnut-Paluxy contact in southern Coryell County is unconformable, but regionally the two units are probably time equivalents. The Fredericksburg-Trinity and Fredericksburg-Washita contacts are interpreted to be unconformities.

The Fredericksburg Division contains 12 basic facies. The horizonal and vertical distribution of these facies is shown by a series of lithotope maps, and the Fredericksburg is interpreted as a cyclic unit with a series of land-derived quartzose or argillaceous units thickening from north to south, blanketed by deeper water lime muds. The Edwards rudistid facies progressed from south to north.

INTRODUCTION

The Fredericksburg Division of the Comanche Cretaceous crops out along a narrow band from Austin to the Texas-Oklahoma boundary. South and west of Austin, Fredericksburg strata underlie one of the most prominent physiographic features of the State, the Edwards Plateau.

The Fredericksburg of north-central Texas is characterized by basal sands and interbedded marl, clay, and limestone units. Equivalent rocks on the Edwards Plateau consist of massive limestone with little land-derived material. The part of south-central Texas under consideration in this paper is transitional between the two, and knowledge of the detailed stratigraphic relationships of the Fredericksburg in the south-central area is basic to the proper determination of stratal equivalents in the plateau area to the west and in the subsurface to the south.

The aims of the present study are (a) to outline the detailed stratigraphic framework, (b) to analyze and plot the distribu-

[1] Shell Development Company, Houston, Texas.

tion of the facies involved, and (c) to reconstruct the geologic history of the Fredericksburg in south-central Texas. It is hoped that the results will contribute to a more complete understanding of the Fredericksburg Division in Texas.

The area of investigation is on the west flank of the Tyler basin, lies to the south and east of the Llano uplift, and is west and north of the Balcones fault system (fig. 1). The regional dip is normally less than one degree to the southeast. The area covers parts of Comal, Hays, Blanco, Travis, Williamson, Burnet, Bell, Coryell, and Lampasas counties (fig. 3).

Procedures.—The stratigraphic sections (Pls. 17–19, in pocket) upon which this paper is based were measured by hand level and steel tape during the spring and summer of 1961.

The field notes consisted of a detailed scale drawing of the weathering profile upon which, by means of symbols, were noted all fossils, bedding characteristics, sedimentary structures, and rock types. Rock samples were taken at each significant lithologic change. Each rock sample was slabbed, etched with dilute hydrochloric acid, and polished on one side with a lap. The samples were described with the use of a binocular microscope and the description augmented, where necessary,

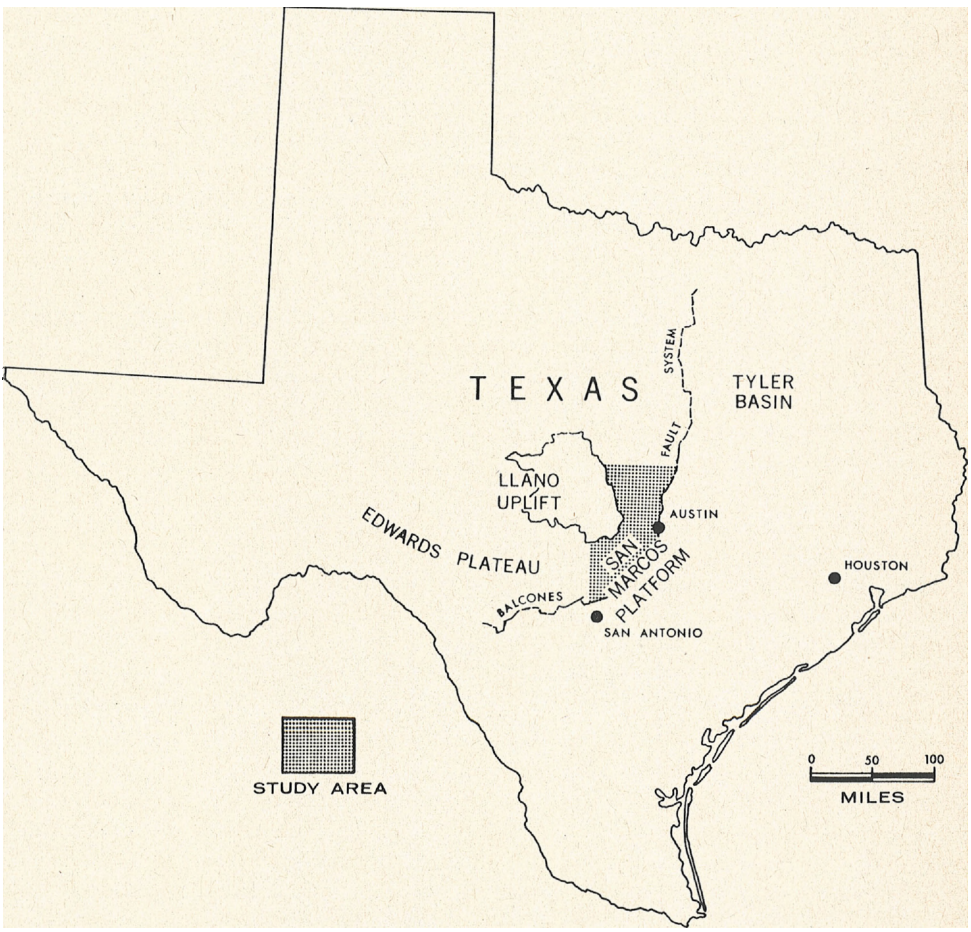


Fig. 1. Regional geographic and tectonic features of central Texas.

by peels and thin sections. The detailed descriptions were combined with the field notes, and a general description of the bed or group of beds was made and placed directly upon the drafted weathering profile. These profiles were the basis of the detailed correlations and facies relationships described in this paper.

Acknowledgments.—The writer is indebted to Prof. Keith P. Young, of The University of Texas, for the over-all supervision of this study; to Dr. Frank E. Lozo, Shell Development Company, Houston, Texas, for editorial assistance and many helpful suggestions; and to Mr. George H. Coates, San Antonio, Texas, for the financial assistance that made this study possible. To the many others who have contributed, the writer expresses his sincere appreciation.

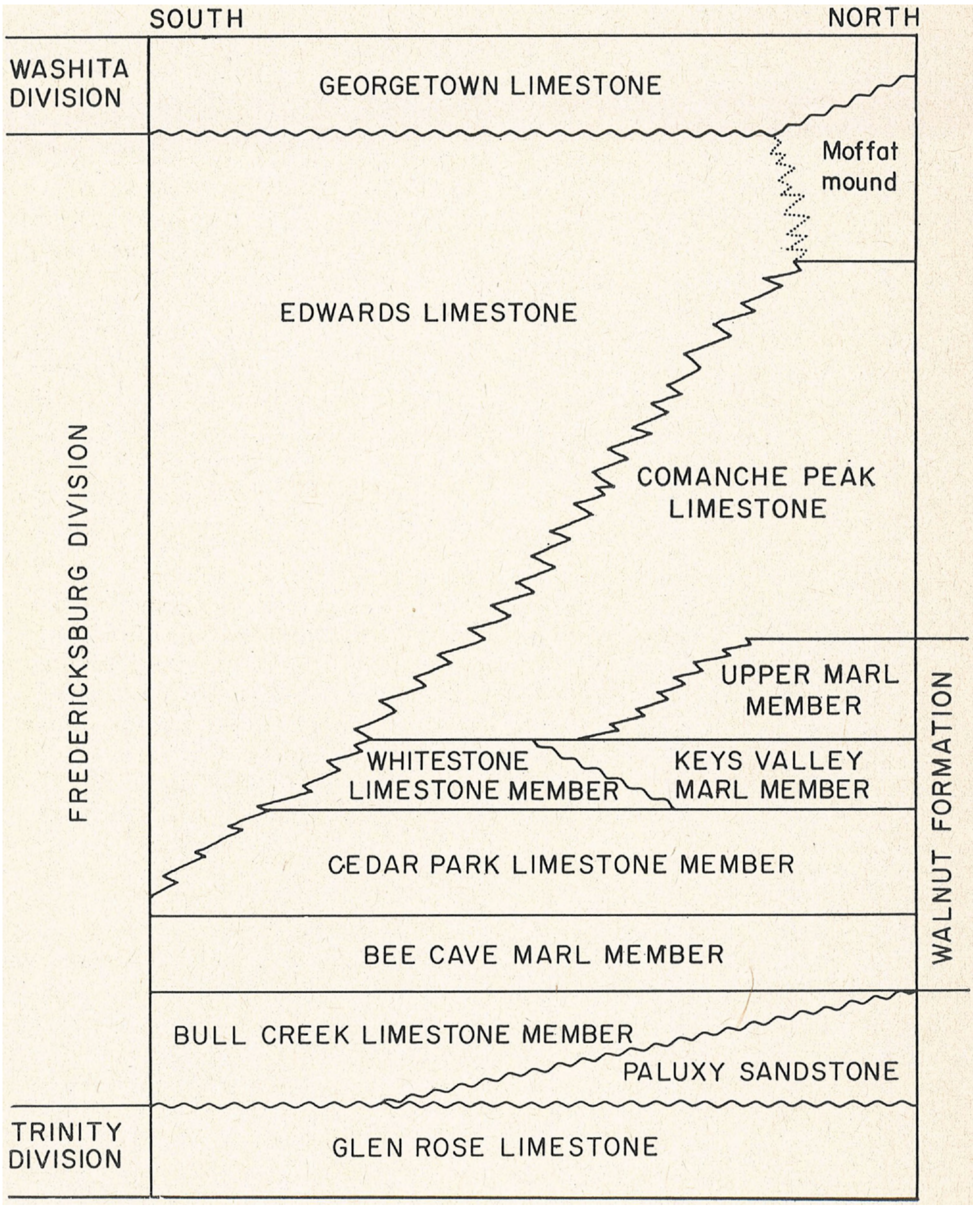


FIG. 2. Stratigraphic units, south-central Texas.

STRATIGRAPHY

Stratigraphic Units

The stratigraphic units (fig. 2) treated in this paper are below the Georgetown Limestone (Washita Division) and above the Glen Rose Limestone (Trinity Division) and comprise the Fredericksburg Division of the Comanche Cretaceous. In descending order the sequence is composed of the Edwards, Comanche Peak, and Walnut Formations, and, in the most northern part, the Paluxy Sandstone.

The boundaries of the Fredericksburg have long been in dispute in central Texas. The formations included within this unit vary with the criteria applied for their recognition, that is, paleontologic versus lithologic or a mixture of the two (Lozo, 1959, p. 3). This confusion supports the thesis that the Fredericksburg has outgrown its *group* status and currently is used, in many cases, as a time-stratigraphic unit rather than a rock unit (note also Murray's (1961, pp. 307, 319) attempt to erect a "Fredericksburgian Stage"). The term *division* and the time-stratigraphic concept as originally applied by Hill (1889, p. x; 1901, p. 113; 1937, p. 79) and as reemphasized by Lozo and Stricklin (1956) and Lozo (1959) in effect relate to a physically defined subseries that is the counterpart of a stage which is historically based on paleontologic criteria. Since the Code of Stratigraphic Nomenclature (1961, pp. 657–659) does not distinguish between physically defined and paleontologically defined time-stratigraphic units, the term Fredericksburg Division (original usage of Hill) is used in this paper.[2] It must be emphasized that the concept of the *division* does not supplant the historic European stages (Albian, Aptian, etc.) long in use in central Texas but is used as another separate time-stratigraphic unit which lends itself to detailed physical stratigraphic analysis on a regional scale.

[2] The author's use of Division does not indicate official adoption of this term by the Bureau of Economic Geology.

SYNOPSIS OF NOMENCLATURE

R. T. Hill (1891) introduced most of the formation names currently in use in central Texas in a paper entitled "The Comanche Series of the Arkansas-Texas Region." The following discussion briefly outlines the origin and usage of the lithic units in south-central Texas; for a more thorough treatment, see Adkins (1933) and Lozo (1959).

Georgetown Limestone.—Hill (1901, p. 262) named the Georgetown Limestone from exposures in the vicinity of Georgetown, Williamson County. The name Georgetown is applied south of the Brazos River to the thinned equivalent of the marl and limestone sequence (Kiamichi to Main Street Formations, inclusive) in north Texas.

Edwards Limestone.—Hill and Vaughan (1898a, p. 2; 1898b, pp. 227–235) applied the name Edwards to the cherty, rudistid-bearing limestone between the Kiamichi (or Georgetown) and the Comanche Peak Formations in north-central and central Texas. This name replaced the earlier "Caprina limestone" of Shumard (1860) and the "Barton Creek limestone" of Hill (1889, p. 5). The type locality was designated as Barton Creek, near Austin, by Adkins (1933, p. 339).[3]

Comanche Peak Limestone.—Shumard (1860) first introduced the geographic name Comanche Peak as a group term which included the present Comanche Peak, Walnut, and Glen Rose Formations. Hill (1891, pp. 504, 512–513) restricted the Comanche Peak to the limestone between the Edwards ("Caprina limestone")

[3] The name Edwards was taken from the physiographic region, the Edwards Plateau, which in turn takes its name from Edwards County. The county was named in honor of Hayden Edwards, an early colonizer (Texas Almanac, 1961–1962, p. 49). This was an unfortunate stratigraphic name selection for the "Caprina limestone" because the assumed relationships between the Edwards Limestone of central Texas and the Edwards Plateau were vague then and are now known to be quite erroneous. The Edwards, thus, has a namesake locality (Edwards Plateau) and a designated type locality (Barton Creek) but still lacks a detailed and complete type section.

and Walnut Formations. The type locality of the white, nodular Comanche Peak Limestone is at Comanche Peak, Hood County, southwest of Fort Worth.

Walnut Formation.—Hill (1891, pp. 504, 512) named the Walnut from outcrops near the town of Walnut (presently called Walnut Springs) in Bosque County. The unit had previously been called *Exogyra texana* clays, *Texana* beds, and *Gryphaea* rock. The definition was further clarified by Hill (1901, pp. 205–206) by including within the formation (in addition to the paleontologically named beds above) the clay, shell agglomerate, and nodular or flaggy limestones below the Comanche Peak.

In south-central Texas the Walnut lies upon the Paluxy or, where the Paluxy is absent, upon the Glen Rose. The Walnut of this area is a sequence of distinctive marl and limestone units generally regarded by workers in this area as members. The writer (1961, p. 17) has designated the lower limestone and lower marl units as the Bull Creek and Bee Cave Members, respectively. The middle limestone unit, named the Cedar Park Member by Adkins (1933, p. 331) is emended herein by defining the upper part as the Whitestone Limestone Member. The upper argillaceous member of Ikins (1941) and others, at the top of the Walnut in Williamson and Bell counties, is referred to the proposed Keys Valley Member and an overlying unnamed marl member.

Paluxy Sandstone.—The Paluxy was named by Hill (1891, pp. 504, 510–511) from exposures along the Paluxy River in Erath County and on the highlands near the town of Paluxy, Hood County. The southernmost Paluxy outcrop is along a line from Burnet to Waco. This "feather edge" of quartz sand is only in the northern portion of the study area.

Glen Rose Limestone.—Hill (1891, pp. 504, 507–509) named the Glen Rose from exposures in the vicinity of Glen Rose, Somervell County. The name replaced the earlier designation "Alternating Beds," derived from the topographic expression of alternating bench-forming ledges and intervening slopes.

Stratigraphic Relationships

The Fredericksburg in south-central Texas can be divided into three stratigraphically distinct areas (fig. 3). The southern area is in Travis, Hays, Comal, and Blanco counties; the intermediate area consists of Williamson and eastern Burnet counties; and the northern area comprises Bell, southern Coryell, and Lampasas counties. Detailed stratigraphic relationships of the Fredericksburg in each area are presented below; figures 6 and 7 and Plate 16 (in pocket) will aid in following the text and the regional relationships discussed.

SOUTHERN AREA

The Fredericksburg of the southern area consists of the Walnut Formation, little or no Comanche Peak Limestone, and a thick Edwards section. Two measured sections illustrate the stratigraphic sequence in the southern area: The Shingle Hill section (Moore, 1959, p. 80) (section 26, fig. 6) is the local section representative of the center of the area; the Whitestone section (section 4, Pl. 17) is transitional between the southern and intermediate areas. The detailed stratigraphic relationships of the Fredericksburg in Blanco, Hays, Comal, and eastern Travis counties were discussed by the writer in 1961. The major points are summarized below:

(1) Two members of the Walnut were recognized; the basal Bull Creek Limestone and the overlying Bee Cave Marl.

(2) The Bull Creek Limestone unconformably onlaps the Glen Rose to the northwest and west; this unconformity seems to die out to the south (Comal County) and the Bull Creek and Glen Rose intercalate.

(3) The Bee Cave Marl thins to the southwest; it contains more clay and fewer nodular interbeds to the north.

(4) In Kendall and Kerr counties, the Edwards Limestone makes up almost all

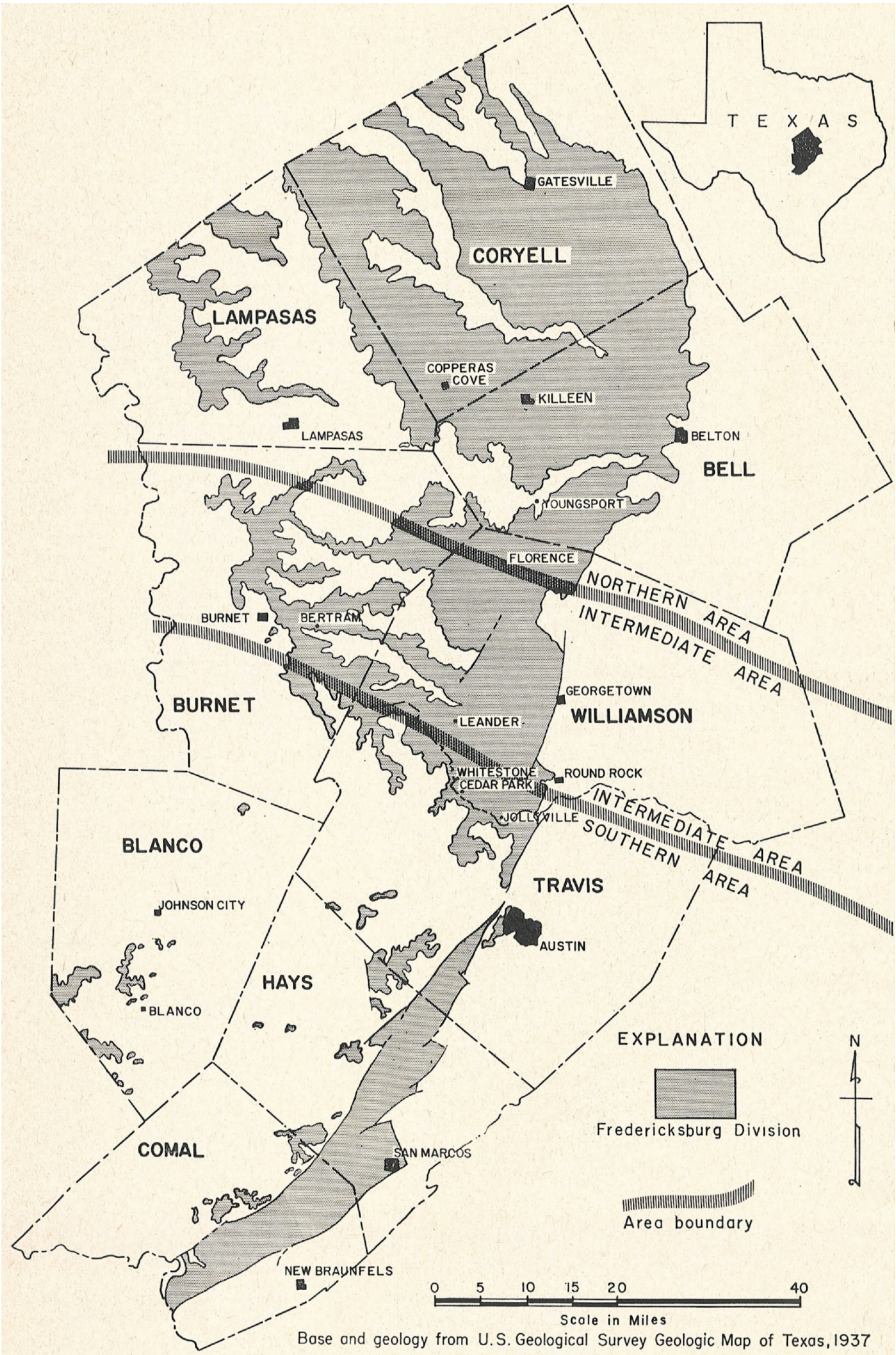


FIG. 3. Index map, south-central Texas.

of the Fredericksburg of the region studied to the east and north.

These conclusions are presented in figures 6 and 7 and Plate 16 (in pocket).

Though the area from Austin to the Williamson County line was not studied in detail by the writer in 1959 and 1961, some assumptions were presented on the Comanche Peak—upper Walnut relationships in this area, namely, (a) that the Cedar Park Limestone Member of the Walnut Formation intercalated with the Comanche Peak north of Austin, and (b) that the nodular limestone directly above the Bee Cave Member at Austin was the Comanche Peak Limestone (Moore, 1961, p. 32). Subsequent detailed studies alter these earlier assumptions, as follows:

1. Adkins (1933, p. 331) named the Cedar Park Limestone Member of the Walnut from exposures in quarries 2 miles northwest of Cedar Park in Williamson and Travis counties and described the member as about 125 feet thick in the type area and consisting of crystalline limestone above and nodular, fossiliferous limestone below. During the present investigation, in the vicinity of the type section, it was found that Adkins' Cedar Park consists of 43 feet of fossiliferous pelsparite and oosparite underlain by 37 feet of nodular, fossiliferous micrite (section 4, Pl. 17). The upper sparry unit is lenticular in shape, 5 to 10 miles wide, and extends generally along the Williamson-Travis County line from the vicinity of Jollyville to a position just north of Burnet in Burnet County (fig. 4). The basal nodular part of the Cedar Park is a widespread, easily recognizable unit of constant thickness and lithic character throughout the intermediate and northern areas. This nodular limestone is generally considered to be the Cedar Park Limestone Member north of the Williamson-Travis County line, and the writer here restricts the name Cedar Park to the lower nodular unit. The upper pelsparite and oosparite lentil is here named the Whitestone Limestone Member of the Walnut.[4] The type localities of both units are where Adkins first described the original Cedar Park; it is recommended that the Whitestone section (section 4, Pl. 17), Travis and Williamson counties, be used as the type section and standard of reference for the emended Cedar Park and Whitestone Members.

2. The Keys Valley Marl Member of the Walnut, a unit that normally rests upon the emended Cedar Park, seems to onlap or drape across the northern flank of the Whitestone and is not present south of its crest (figs. 4, 6). The proposed Keys Valley is described later.

3. The Comanche Peak Limestone thins abruptly across the Whitestone, intercalates with the Edwards at the crest, and is not present to the south (figs. 4, 6).

4. The emended Cedar Park Member is continuous with the nodular limestone occurring just above the Bee Cave Marl at Austin. This nodular limestone, the middle limestone member of the Walnut of Ikins (1941, 1949), should not be referred to the Comanche Peak.

INTERMEDIATE AREA

The Fredericksburg of the intermediate area (Williamson and eastern Burnet counties) consists of a thick Walnut Formation divided into four marl and limestone units (fig. 2), a thick Comanche Peak Limestone, and a thin Edwards sequence. The North San Gabriel section (no. 8, Pl. 17), Williamson County, is typical of this region. Local stratigraphic details in the intermediate area are presented in the following discussion.

[4] The Whitestone Limestone Member since 1928 (Wall, 1955, p. 18) has been quarried intensively for building stone at the Cedar Park quarries, Williamson and Travis counties. Two principal varieties sought are the oolitic limestone occurring at the top of the lentil, known to the building trade as *Cordova Cream* (Pl. 1, A), and the *Trigonia*-rich beds just below the Cordova Cream, known as *Cordova Shell* (Pl. 1, B). The stratigraphic position of these two varieties is shown on the Whitestone section (section 4, Pl. 17).

Split stone veneer used in residences in and around Austin also comes from the Whitestone at the Cedar Park quarries and is known commercially as *Austin Stone*. This designation has led to confusion with limestones of the Upper Cretaceous Austin Group.

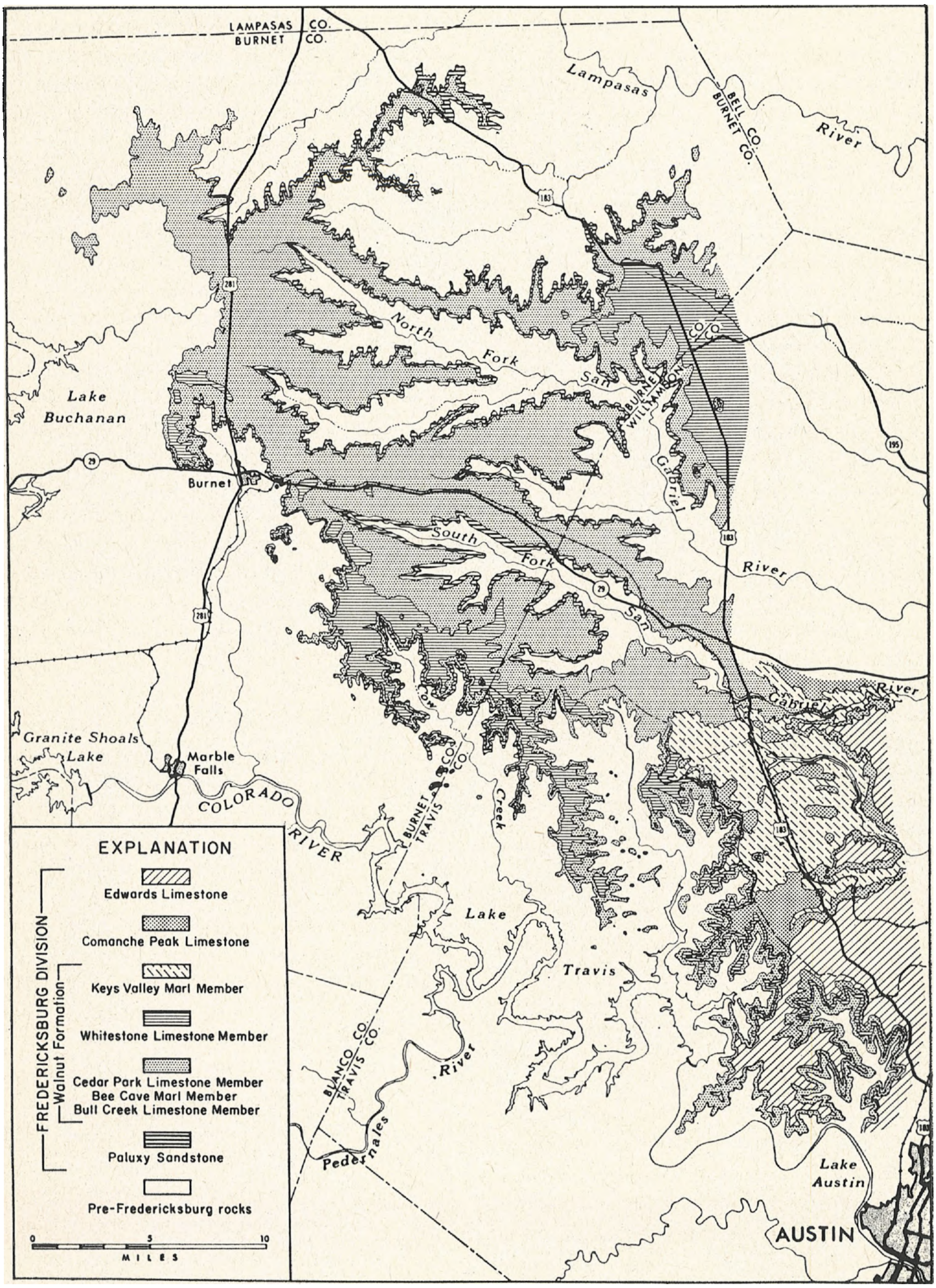
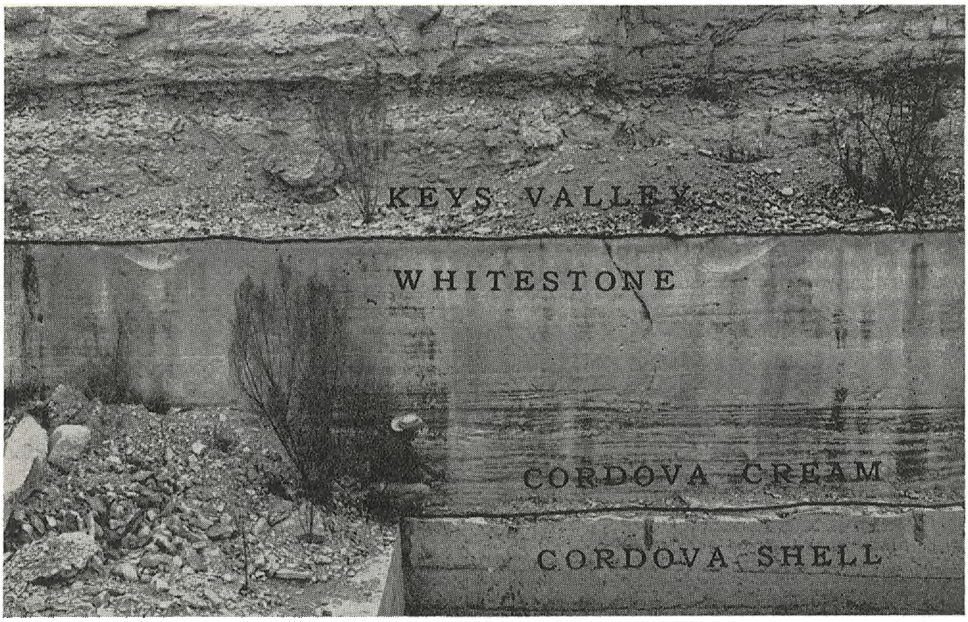


FIG. 4. Geologic map of parts of Burnet, Williamson, and Travis counties, Texas.



(A) Quarry exposure of the Whitestone. The *Trigonia* stone, or Cordova Shell, is at the base; the oolitic phase, or Cordova Cream, is at the vertical face above the man shown; the Keys Valley Marl is at the top.

(B) *Trigonia* stone, or Cordova Shell; matrix is composed of pellets and rounded shell fragments.

Whitestone Limestone Member of the Walnut Formation, abandoned quarry, 1.8 miles west of Whitestone, on Ranch Road 1431, Williamson County, Texas.

Glen Rose—Walnut contact.—The Glen Rose—Walnut contact is between dolomite below and nodular limestone above and appears to be a disconformity in the intermediate area. The following criteria support this conclusion:

1. Pholad borings are abundant on the top surface of the Glen Rose throughout the intermediate area (Pl. 2, A). Oysters are commonly cemented to the surface.
2. Dinosaur tracks, mud cracks, pholad borings, and cemented oysters occur together on this surface along the San Gabriel River, 2.1 miles north of Leander, Williamson County (Pl. 2, B).
3. Bored pebbles and cobbles occur in beds directly above the contact in the North San Gabriel section, Williamson County.

Bull Creek Limestone Member of Walnut Formation.—The Bull Creek retains the same lithic character and thickness relationships as observed to the south. A bored surface[5] reported at the top of the Bull Creek in the southern area (Moore, 1961, p. 25) is not present in the intermediate area. A reworked zone, however, with bored pebbles and a fragmented *Exogyra texana* hash occurs at the same stratigraphic level in the western portion of the intermediate area.

Bee Cave Marl Member of Walnut Formation.—The Bee Cave changes markedly from outcrops in the vicinity of Austin; it is much more nodular, contains less clay, and has considerably fewer fossils. The *Dictyoconus walnutensis* bed (Moore, 1961, p. 28), a nodular limestone with numerous *D. walnutensis* (Carsey) near the top of the Bee Cave and a key bed throughout the southern area, is replaced by soft marl and clay in the northern and western parts of the intermediate area.

Cedar Park Limestone Member of Walnut Formation.—The Cedar Park—Bee Cave contact is placed at the base of the lowest nodular, massive, fossiliferous micrite (Pl. 3). Pholad borings are abundant on top of the Cedar Park northward from the North San Gabriel River in central Williamson County. Bored pebbles are commonly associated with this surface. South and west of the North San Gabriel River the borings are not present; however, the surface can be traced to the Williamson-Travis County line. The Whitestone is developed upon this surface. The Cedar Park is 40 feet thick throughout the intermediate and northern areas. In the southern area it intercalates with the expanded Edwards Limestone.

Keys Valley Marl Member (new name) of Walnut Formation.—Horne (1930) recognized an upper clay or marl member of the Walnut Formation. The term Keys Valley Marl is here proposed for this upper marl in order to avoid confusion with another unit in Bell County (a marl wedge) between the Comanche Peak Limestone and this locally uppermost Walnut marl. The Keys Valley Marl is named for a small settlement just across a bridge over the Lampasas River on the Union Grove—Belton road in Bell County, 6 miles west-southwest of Belton. The outcrop chosen as typical of this unit is a road cut 20 feet north of the bridge (Pl. 4, A). Location of this type section (no. 32, Pl. 19) is shown on figure 12.

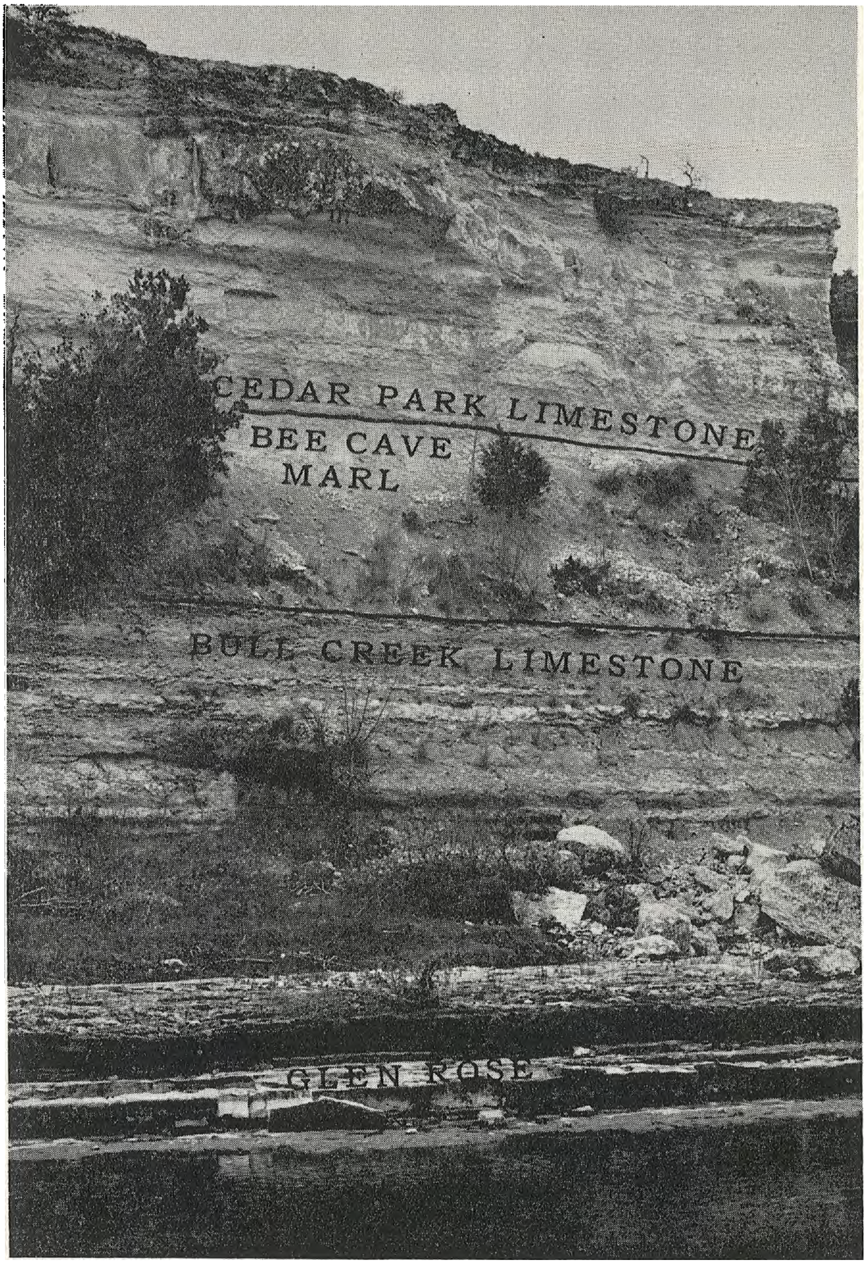
The Keys Valley Member is a marl and nodular limestone unit with an average thickness of 35 feet in the intermediate area. The unit has an abundant fauna composed of gastropods, pelecypods, echinoids, oysters, and ammonites. Midway in the unit there is a concentration of *Oxytropidoceras* sp. that forms a distinctive zone throughout the area. A 5- to 10-foot lumachelle of *Gryphaea mucronata* (Gabb) occurs at the top of the unit and forms a distinctive bench (Pl. 4, B) throughout western Williamson County. As mentioned in the discussion of the southern area, the Keys Valley Marl pinches out at the crest

[5] Bored surfaces indicate to the writer a period of subaerial exposure allowing the lithification of lime mud or ooze. In the situation described in this work (widespread, shallow carbonate shelf sequence), such surfaces should be expected throughout the stratigraphic section. Evaluation of the significance of regional unconformity surfaces versus those of local character is based on (a) extent of the surface, (b) physical features associated with or on the surface, and (c) regional relationships above and below the surface.

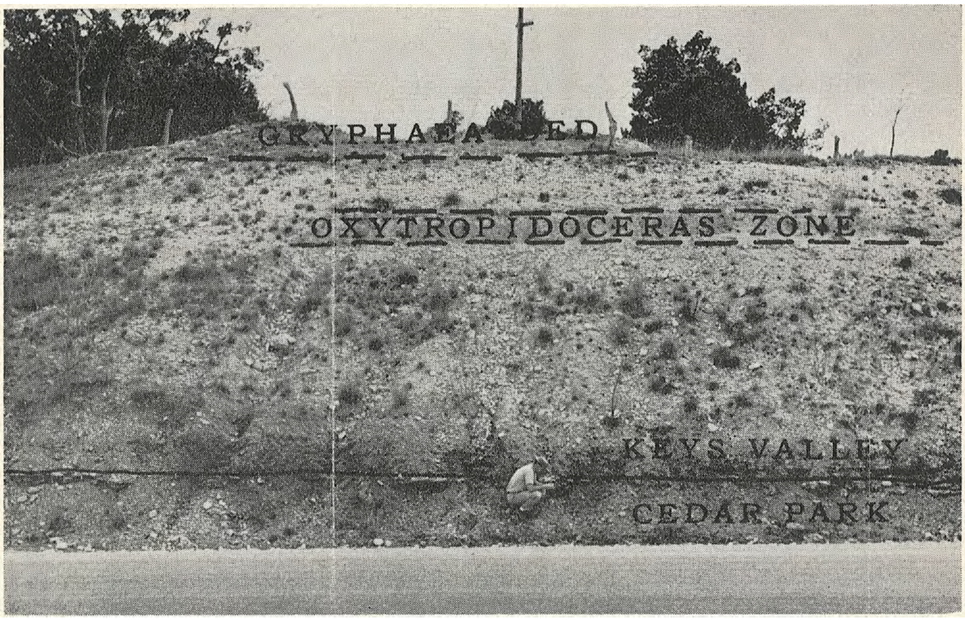
(A) Pholad borings—South San Gabriel River, near Leander, Williamson County.

(B) Dinosaur track and mud cracks—South San Gabriel River, near Leander, Williamson County.

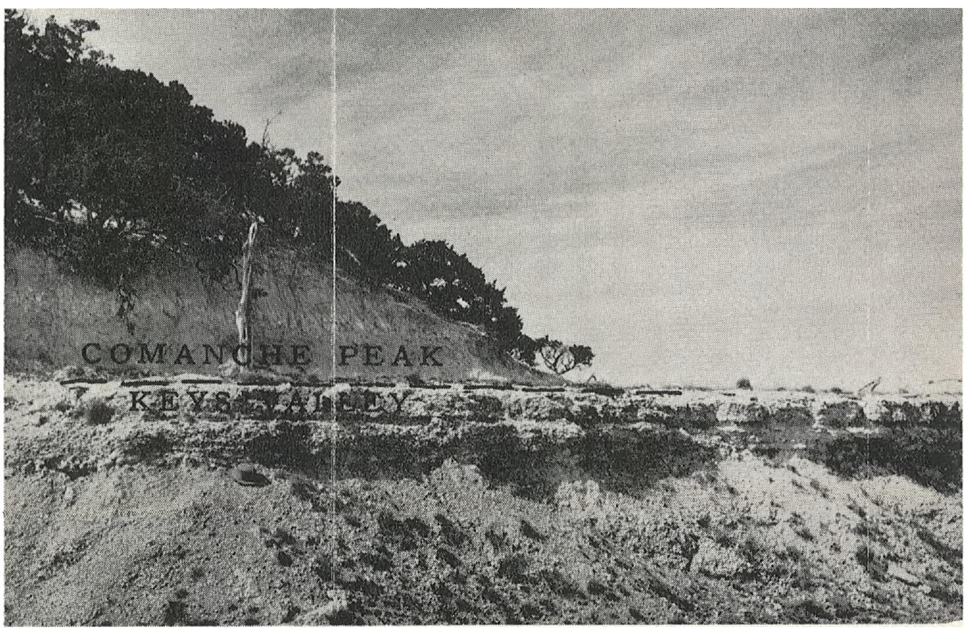
Features on the top surface of the Glen Rose Limestone, 2.5 miles north of Leander, just east of U. S. Highway 183 bridge over the South San Gabriel River, Williamson County, Texas.



Lower Fredericksburg outcrop, from top of Glen Rose (at river level) to top of Cedar Park (top of cliff), 2.5 miles north of Leander, just west of U. S. Highway 183 bridge over the South San Gabriel River, Williamson County, Texas.



(A) Type locality of the Keys Valley Marl Member, 0.3 miles west of the Keys Valley Baptist Church on Ranch Road 1670, 6 miles southwest of Belton. Keys Valley—Cedar Park contact is at man's shoulders; the *Oxytropidoceras* zone is midway up the cut, and the *Gryphaea* bed is at the top.



(B) *Gryphaea* lumachelle at Horsethief Mountain, 1.4 miles south of Youngsport on the Florence-Youngsport road. Ledge is top of Keys Valley Marl Member; Comanche Peak Limestone is in the left background.

Keys Valley Marl Member of the Walnut Formation, Bell County, Texas.

of the Whitestone and is not present south of Williamson County.

Comanche Peak Limestone.—The nodular Comanche Peak Limestone thickens abruptly north of the Williamson-Travis County line, interfingering with the Edwards above and, to a much lesser degree, with the Keys Valley Marl below. The base is marked by a massive, nodular limestone bed which generally forms steep cedar-covered slopes (Pl. 4, B). The Comanche Peak is of uniform composition with relatively few fossils and other allochems.

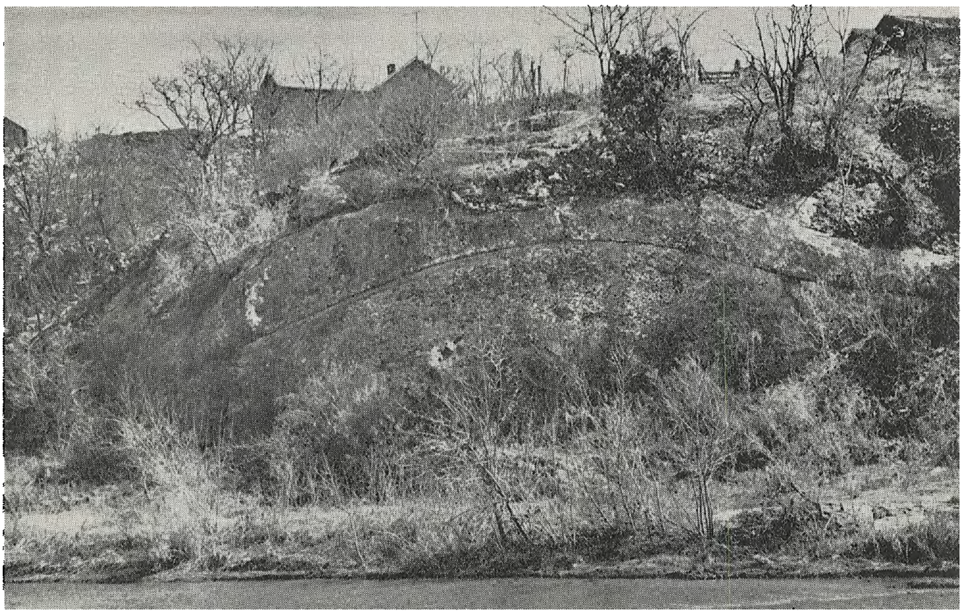
Edwards Limestone.—The Edwards Limestone thins northward from the Williamson-Travis County line. At the southern edge of Williamson County the Edwards is possibly 160 feet thick, at the North San Gabriel section, Williamson County (section 8, Pl. 17), it is 130 feet thick, and at the Williamson-Bell County line it is 90 feet thick. The Edwards exposed in the intermediate area is generally badly recrystallized and dolomitized. Since Nelson (1959) made an exhaustive study of diagenesis within the Edwards from Williamson to McLennan counties, the present paper deals only with data that could be obtained from the occasional exposures of unaltered Edwards Limestone. In those exposures where original limestone textures remain, only the general sequence of rock types was determined. The Edwards in the intermediate area consists of rudistid biostromes and thin, hard, miliolid biosparite and biomicrite with associated nodular chert. Bioherms at the base of the Edwards are exposed on the South San Gabriel River at Georgetown, Williamson County (Pl. 5).

Edwards-Georgetown contact.—In the intermediate area, the top surface of the Edwards Limestone commonly has abundant pholad borings. Table 1 lists accessible exposures of this surface and associated features.

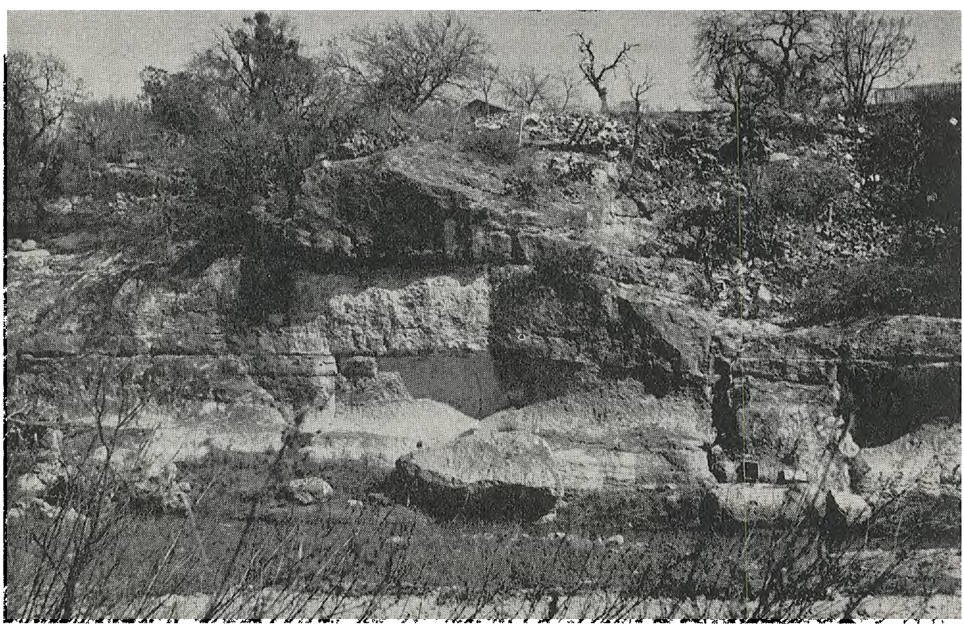
The Brushy Creek locality at Round Rock (table 1) has been described as having 4 to 5 feet of Kiamichi(?) above the Edwards (Shreveport Geol. Soc., 1949, pl. 8). This unit contains *Oxytropidoceras* n. sp., *O.* (*Adkinsites*) cf. *O.* (*A.*) *belknapi* (Marcou), and *O.* (*Adkinsites*) cf. *O.* (*A.*) *bravoense* (Böse), an association which elsewhere in northeast Texas does not generally occur above the Kiamichi but can occur below. The clay at Brushy Creek containing these ammonites is above the locally disconformable top of the Edwards and is thus assigned to the Georgetown. The southernmost exposure of the continuous Kiamichi is at the Coryell-Bell County line. The clay at Brushy Creek does not extend any appreciable distance north or south (the clay seems to pinch out, but poor exposures preclude finding the exact stratigraphic relationship) and is truncated by a fault of the Balcones system on the east. Although the clay could be a reentrant of the once-continuous Kiamichi from the subsurface to the east, the writer prefers to avoid the more specific (even if questioned) designation of Kiamichi. Pending further work, these beds are considered a local clay unit of undifferentiated Georgetown, perhaps the basal member (Kia-

TABLE 1.—*Localities and associated features of the Edwards-Georgetown contact.*

LOCALITY	FEATURES
Berry Creek, 2 miles north of Georgetown, Williamson County	Pholad borings into the top surface of the Edwards
San Gabriel River, just east of U. S. Highway 81 bridge at Georgetown, Williamson County	Pholad borings into the top surface of the Edwards
Brushy Creek, just west of the old U. S. Highway 81 bridge at Round Rock, Williamson County	Pholad borings into the top surface of the Edwards. Bored pebbles in bed above contact.
McNeil quarries on the Williamson-Travis County line, southwest of Round Rock	Pholad borings into the top surface of the Edwards



(A) Bioherm at base of Edwards.



(B) Bioherm at base of Edwards. Comanche Peak is exposed in the river bed and the contact with Edwards is midway up the cliff.

Edwards bioherms, 0.4 mile west of U. S. Highway 81, just south of Ranch Road 29 bridge over the South San Gabriel River, in city limits of Georgetown, Williamson County, Texas.

michi), and are not thought to be a facies of the Edwards as has been suggested by some workers.

NORTHERN AREA

The northern area includes Bell, southern Coryell, southern Lampasas, and northern Burnet counties. The Fredericksburg in this area is characterized by the appearance of the Paluxy Sandstone, further expansion of the Walnut Formation, and development of the attenuated, biohermal Edwards of north-central Texas. The Southwest Belton section (no. 10, Pl. 18) and the Copperas Cove section (no. 17, Pl. 19) are typical for the area.

Glen Rose—Walnut or Paluxy contact.—Throughout the northern area pholad borings are abundant on the upper surface of the Glen Rose where overlain by the Walnut, and the surface is uneven and generally bored where overlain by the Paluxy. The dolomite representative of the upper Glen Rose in the southern and intermediate areas is replaced by limestone in the northern area. The Glen Rose—Walnut contact is placed at the top of a sequence of thin-bedded, hard, miliolid-bearing limestone that normally forms a distinctive bench below the softer Fredericksburg deposits.

Paluxy Sandstone.—The southern edge of the Paluxy outcrop is in southern Coryell, Lampasas, and Burnet counties (fig. 4). The Paluxy ranges, within the study area, from a few inches to more than 15 feet in thickness and is composed of very fine-grained quartz sand, interbedded sandy clay, and occasional sandy fossiliferous limestone flags (Pl. 6, A). Over most of the area there is an unconformity between the Paluxy and Walnut; the contact is very irregular and there is a concentration of bored, calcareous-cemented quartz sandstone pebbles in the base of the Walnut (Pl. 6, B). This unconformity can be traced northward but is not present beyond Gatesville, Coryell County.

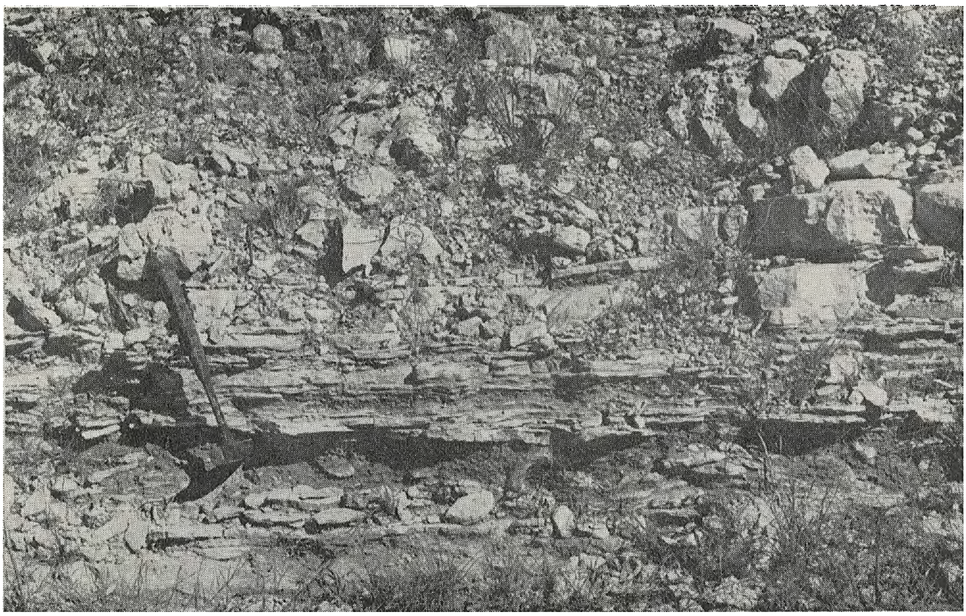
Bull Creek Limestone Member of Walnut Formation.—The Bull Creek is reduced to a thickness of 10 feet in the northern area. The reworked zone present at the upper surface of the Bull Creek in the intermediate area is absent in the northern area and the Bull Creek and Bee Cave possibly interfinger. The Bull Creek is largely a shell-fragment biomicrite with few of the sparry and intraclastic beds that are abundant in the unit in the southern and intermediate areas.

Bee Cave Marl Member of Walnut Formation.—A pronounced change in the lithology of the Bee Cave occurs between the North San Gabriel River and the Bell County line. In the northern area it contains more clay, fewer fossils, and is characterized by thin, shell-fragment biomicrite flags, which commonly have large, well-developed ripple marks on their upper surfaces. These ripples trend generally northwest (Pl. 7).

Cedar Park Limestone Member of Walnut Formation.—The Cedar Park of the northern area is similar to that of the intermediate area except that a thin clay bed is present in the middle of the unit from a point southwest of Belton and continues to the north and northwest. This clay contains a single, thin, ripple-marked shell-fragment biomicrite flag; the clay forms the double bench characteristic of the Cedar Park in the northern area.

Keys Valley Marl Member of Walnut Formation.—The Keys Valley is essentially the same as in the intermediate area. There is some variation in thickness and in the position of the *Oxytropidoceras* zone within the unit. The *Gryphaea* lumachelle near the top of the Keys Valley is the same throughout the northern area as in the northern part of the intermediate area.

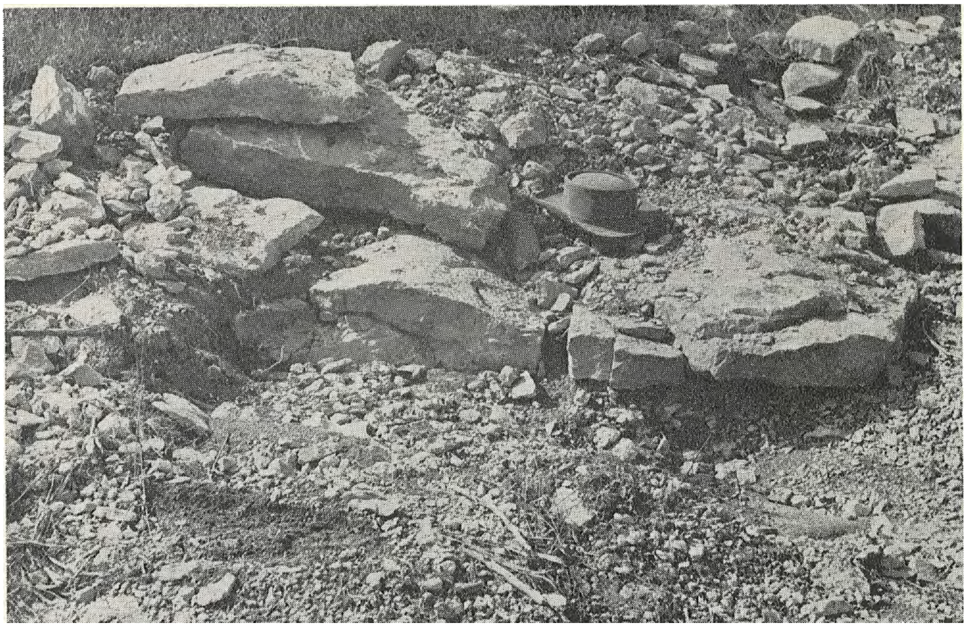
Upper marl member of Walnut Formation.—Another marl and clay unit, distinct from the Comanche Peak Limestone above and the Keys Valley Marl below, occurs southwest of Belton in Bell County. This nodular limestone and marl unit is present throughout the area north of a line drawn through Copperas Cove, Coryell County, and a point about 10 miles southwest of Belton. The best exposure of this unit is



(A) Sandstone flags in the Paluxy, 2.5 miles south of Lake Victor on the Lake Victor—Burnet road.

(B) Contact of Paluxy Sandstone and Walnut Formation, 0.5 mile north of Bertram on Ranch Road 1174. Calcareous-cemented quartz sandstone boulders, with pholad borings, are in right foreground.

Paluxy Sandstone, Burnet County, Texas.



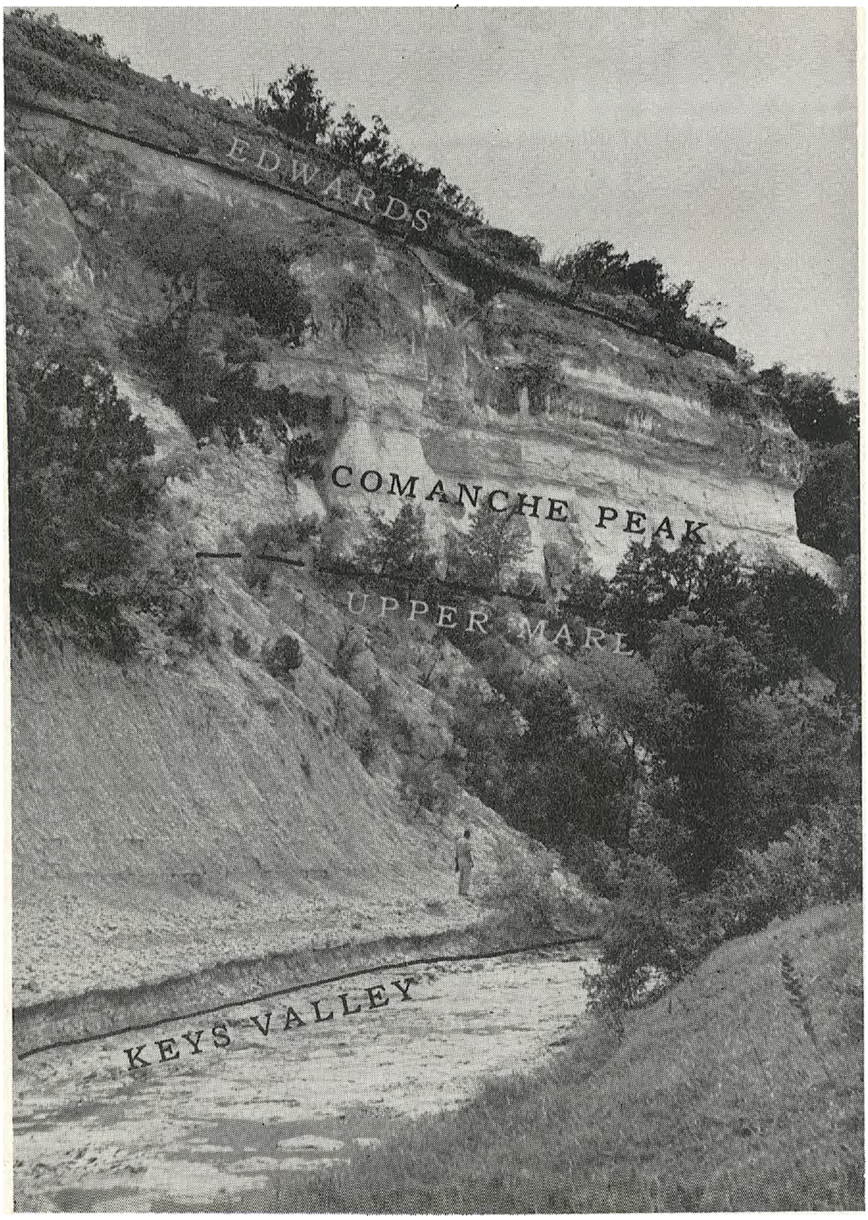
Limestone flags, Bee Cave Marl Member of the Walnut Formation. On the Youngsport-Florence road, 1.2 miles south of Youngsport, Bell County, Texas. The upper surfaces of the flags are large symmetrical ripple marks.

found in a bluff on Owl Creek at Cold Springs, Coryell County, on the Fort Hood Military Reservation (Pl. 8; section 31, Pl. 19). The upper marl member is separated from the Keys Valley Marl Member below by the *Gryphaea* lumachelle previously mentioned. The unit is fossiliferous and contains *Gryphaea mucronata, Exogyra texana,* gastropods, pelecypods, and *Inoceramus.* The Comanche Peak—upper marl boundary is transitional.

The upper marl is lithologically similar to the Keys Valley. The differences between the two units are: (a) The upper marl contains more lime than does the Keys Valley; (b) the fauna of the upper marl is more restricted and less abundant than that of the Keys Valley. Since the upper marl is bounded above by the massive limestone of the Comanche Peak and below by the distinctive, mappable *Gryphaea* lumachelle at the top of the Keys Valley, the writer feels that the upper marl could be a useful mapping horizon in the northern area.

The upper marl has not been given a formal geographic member name because the few exposures in the extreme northern part of the study area are not deemed sufficient to establish the distribution and detailed stratigraphic relationships which are necessary for the erection of a formal stratigraphic unit.

Comanche Peak Limestone.—The Comanche Peak Limestone in the northern area is indistinguishable from the Comanche Peak of the intermediate area. In southern Bell County the formation is 80 feet thick. It maintains this thickness by interfingering with the Edwards even though its stratigraphic position is displaced upward (fig. 6). The upper 30 feet of the Comanche Peak is an oolitic facies near Moffat, northern Bell County, and is considered part of the Moffat mound of the Edwards (fig. 5).



Upper marl member of the Walnut Formation, along Owl Creek, 4.8 miles southwest of Cold Springs just south of Ranch Road 184, Coryell County, Texas. The *Gryphaea* lumachelle marking the top of the Keys Valley Marl Member is in the creek bed; tree line in middle of bluffs marks the contact of the upper marl and the Comanche Peak; Edwards at top of bluff.

Edwards Limestone.—The Edwards Limestone ranges in thickness from 90 feet at the Bell-Williamson County line to 30 feet at the Bell-Coryell County line. North of Moffat, Bell County, the Edwards is thin and consists of rudistid bioherms and thin interbiohermal deposits. The Edwards north of Moffat has been studied in great detail by Nelson (1959). South of Moffat the general appearance of the Edwards is the same as in the intermediate area. The recrystallization encountered in the intermediate and southern areas is present north of Moffat, but farther north the Edwards is generally much less altered.

The south-to-north thinning trend of the Edwards is interrupted at Moffat where the formation is 125 feet thick. This thick Edwards sequence consists of oolite and pellet rocks, a rock type somewhat foreign to the Edwards of this region. This limestone body replaces 30 feet of the Comanche Peak below and extends some 60 feet above the general upper Fredericksburg surface (fig. 6). Nelson (1959, pl. 1) described this anomalous Edwards section and illustrated it as a trough. However, study of the logs of several water wells near Moffat shows that the units beneath the Moffat section, with the exception of the Co-

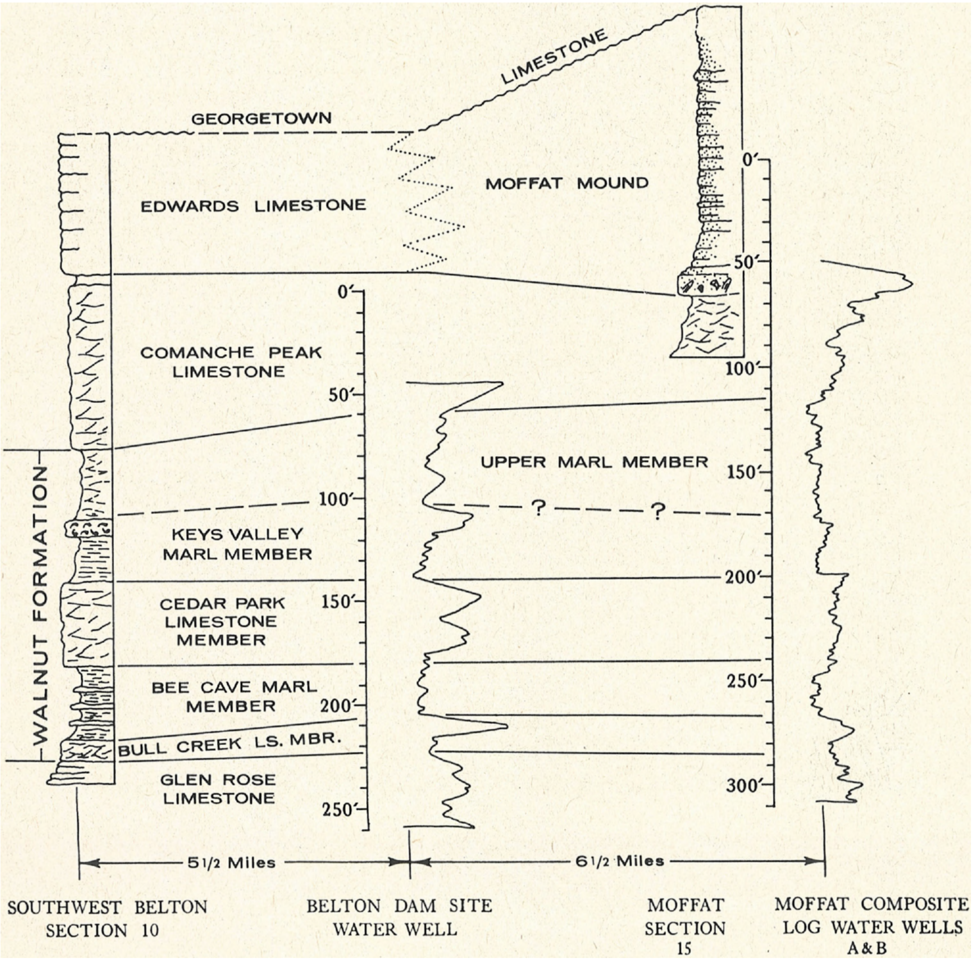


FIG. 5. Stratigraphic relations, Moffat area, Bell County, Texas. Location of sections and water wells shown on figure 12.

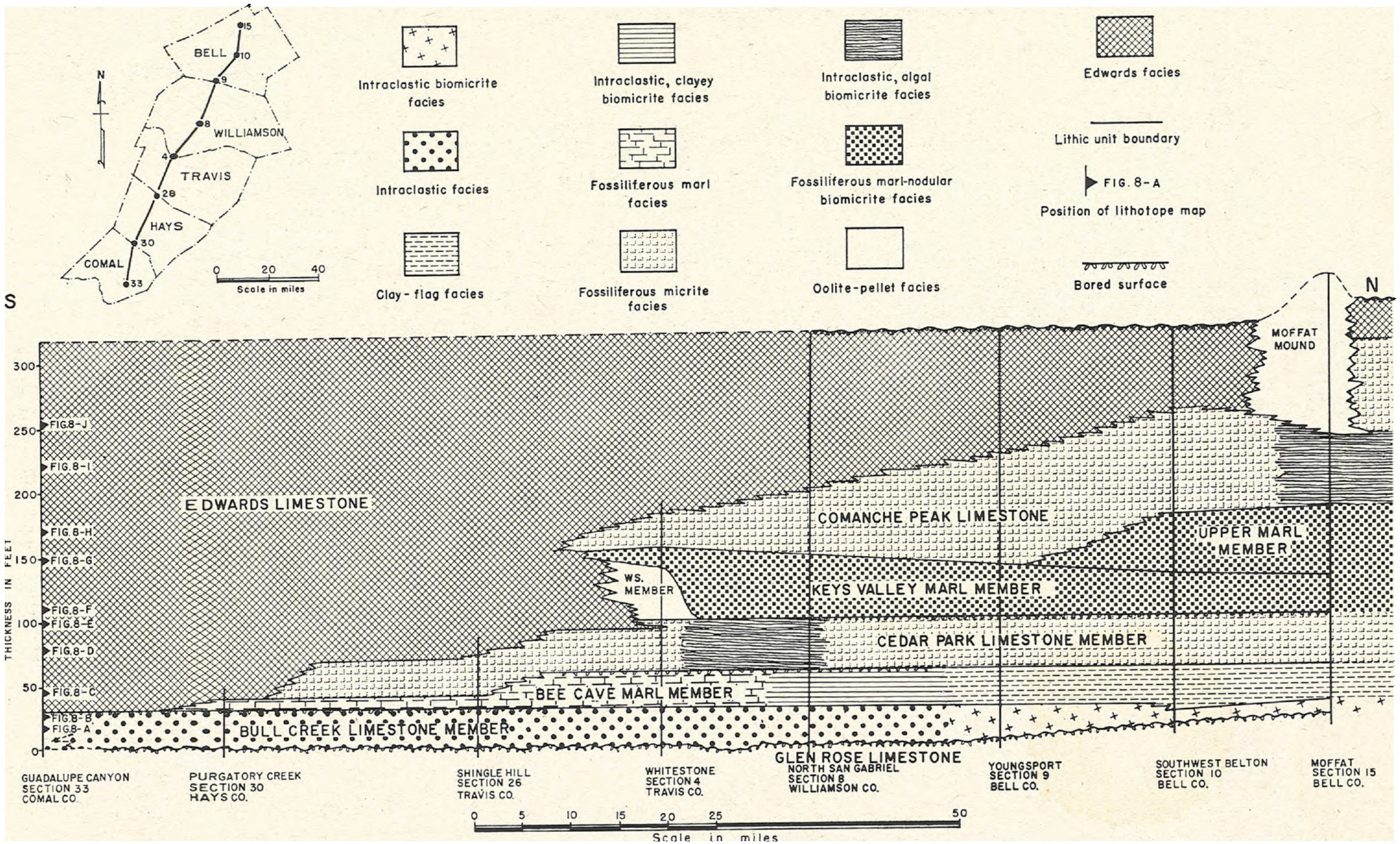


FIG. 6. Stratigraphic cross section: vertical facies distribution, Fredericksburg Division. Sections 26, 30, and 33 are sections 6, 9, and 10, respectively, of Moore (1961).

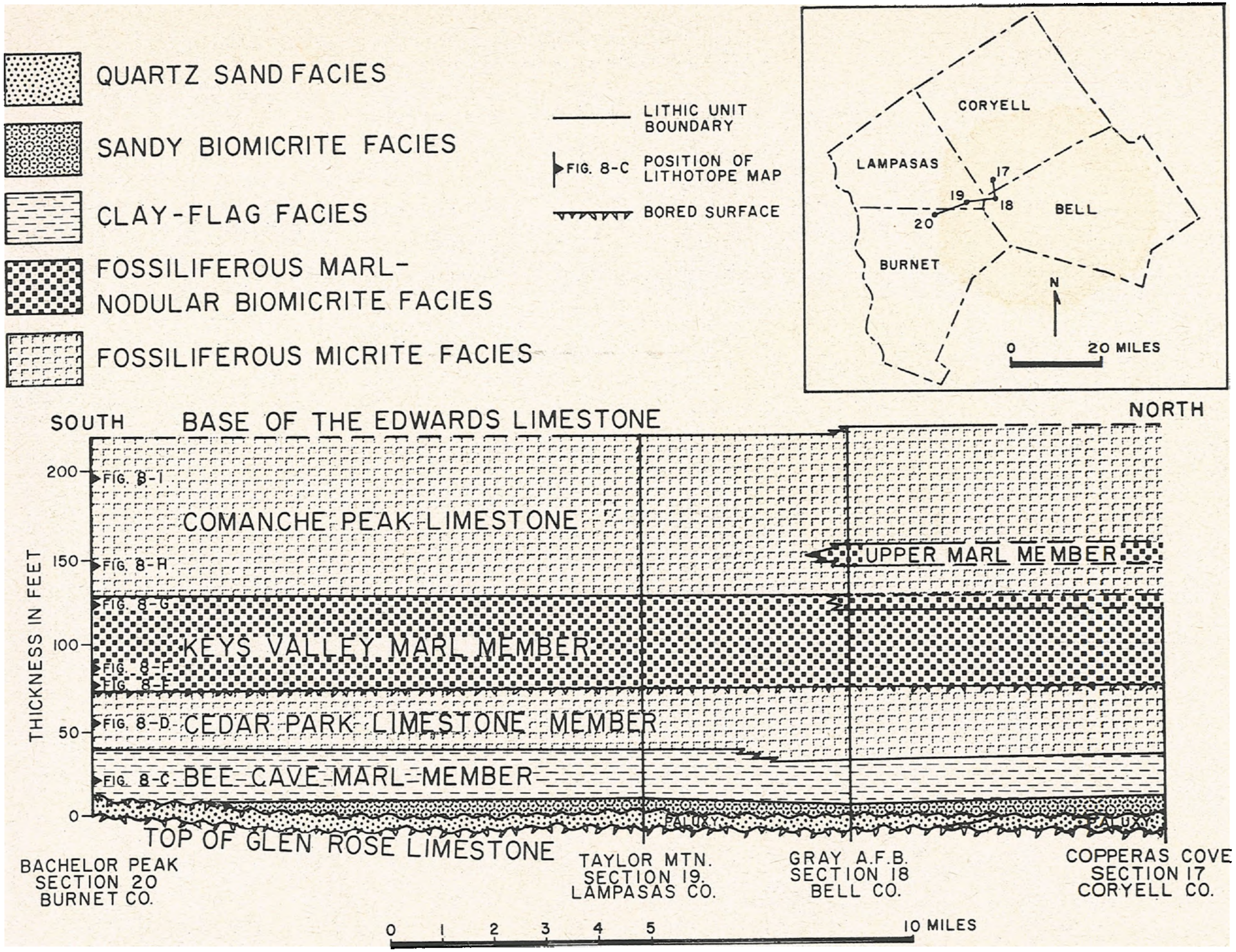


FIG. 7. Stratigraphic cross section; vertical facies distribution, Fredericksburg Division.

manche Peak, retain the thicknesses observed generally in the northern area (fig. 5). If this Edwards lentil was deposited in a trough, it would be expected to replace the entire Comanche Peak and the upper Walnut. Because the Edwards does not, the writer postulates an eminence on the upper Fredericksburg surface in this area. The areal distribution of this uncommon Edwards facies is poorly known because of lack of outcrops; thin Comanche Peak sections in southern Coryell County suggest that the Edwards build-up is elongate in a northwest direction and is lenticular. In the vicinity of Moffat the mound is about 4 miles wide, with an abrupt northern flank much like the Whitestone of the southern area. In this paper the writer will refer to this feature as the Moffat mound of the Edwards.

The top of the Edwards Limestone in the northern area generally is bored by pholads and exhibits other features of interrupted deposition. Adkins (1930, p. 40) described several localities in Bell County where the top of the Edwards is bored or presents other evidence of irregularity. Observations of similar features at additional localities examined by the writer are included in table 2.

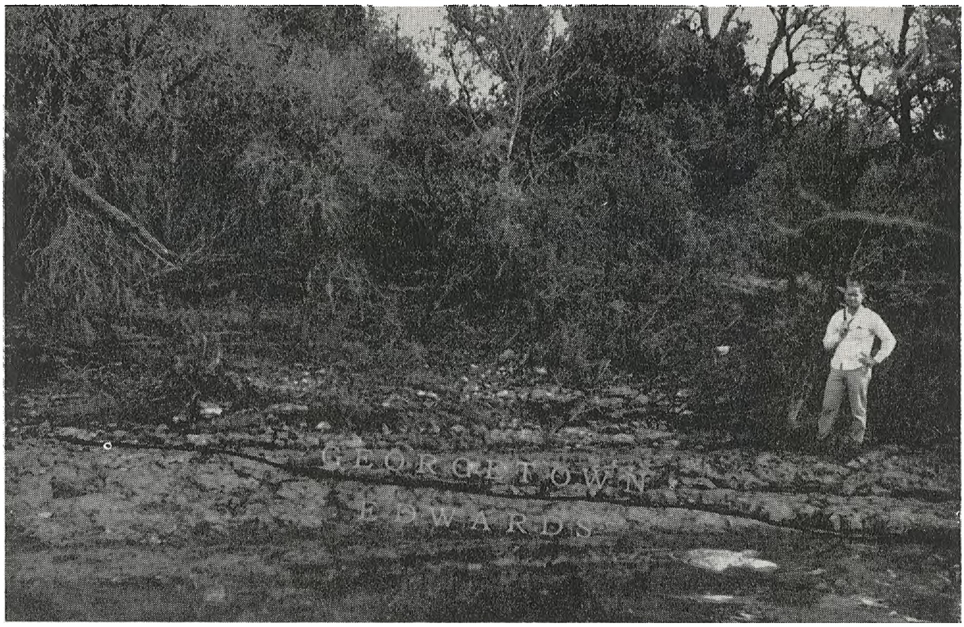
These relationships indicate to the writer that the upper Edwards surface was subaerially exposed prior to the deposition of the Georgetown Limestone.

REGIONAL RELATIONSHIPS

In the preceding pages local stratigraphic sections and the nomenclature for the three areas are outlined. The regional

TABLE 2.—*Features observed at the Edwards-Georgetown contact in Bell County, Texas* (Adkins, 1930, p. 40, and Moore, 1961).

LOCALITY	DESCRIPTION
Nolan Creek and the Leon River east of Belton (= Nolan Creek of Adkins)	"It (the Edwards) is irregularly corroded and pitted, and locally is scoured out to a depth of a foot or so, and the basal Duck Creek rests with uneven nodular bedding upon this scoured surface, with individuals of *Hamites* and *Desmoceras* directly in contact with the top surface of the Edwards. This surface is pitted with borings (molluscan?)."
Cedar Creek in north-central Bell County (Adkins)	". . . the Duck Creek locally overlaps several feet down onto the eroded Edwards."
Downstream from Salado (Adkins)	". . . the top of the Edwards is corroded and pitted and the contact with the Duck Creek is apparently concordant."
Cedar Creek at State Highway 36 bridge (Moore)	The top of the Edwards is very irregular and bored. Chert nodules in the top of the Edwards stick up as small protuberances over which the Georgetown has been draped, thus showing differential erosion on this surface before the deposition of the Georgetown Limestone.
Leon River, at State Highway 36 bridge (Moore)	The top of the Edwards is irregular and bored.
Stampede Creek, 1.6 miles southwest of the Stampede community (Moore)	An Edwards bioherm extends some 15 feet above the general level of the top of the Fredericksburg. Because of poor exposures, the Georgetown relationships on the immediate flanks could not be determined. However, some 300 yards upstream (Pl. 9) the basal beds of the Georgetown onlap a similar mound and the top of the Edwards is irregular and bored.



(A) Onlap of basal Georgetown beds onto an Edwards rudistid mound.

(B) Upper surface of Edwards with abundant pholad borings.

Edwards-Georgetown relationships on east bank of Stampede Creek, 500 yards north of Meador Grove—Whitehall road, 3.2 miles north of Whitehall, Bell County, Texas.

relationships of these units are illustrated in figures 6 and 7 and Plate 16 (in pocket) and are summarized below.

1. The top of the Glen Rose is a surface of wide areal extent in the southern and intermediate areas. The top of the Glen Rose in the northern area is also of wide extent but the two surfaces may not be the same; it is the writer's opinion that they form one continuous datum. This surface, from Kendall County to Coryell County, is interpreted as an unconformity.

2. The Paluxy Sandstone is the northern, near-shore-to-continental analogue of the Bull Creek Limestone Member of the Walnut to the south. In Lampasas, Coryell, and Burnet counties, the Walnut unconformably overlies the Paluxy. The writer agrees with Lozo (1959, p. 18) that this break in sedimentation is of little time significance and only represents marine units progressively onlapping periodically exposed, practically contemporaneous, near-shore terrigenous deposits. In any single outcrop, Walnut overlies Paluxy, commonly disconformably, but regionally Paluxy and Walnut are considered as near-contemporaneous deposits.

3. The Bull Creek Limestone Member of the Walnut is a basal Fredericksburg clastic limestone unit which onlaps the Glen Rose surface to the west and northwest. In the southern area, the top surface of the Bull Creek is bored by pholads. This bored surface is absent to the north, and the Bee Cave and Bull Creek probably interfinger in the northern area.

4. The Cedar Park Limestone Member (emended) is a blanket limestone with wide areal extent and little change in thickness or composition. The unit has been used as a datum over the entire area of the present study.

5. The argillaceous units of the Walnut Formation (Bee Cave Marl Member, Keys Valley Marl Member, and unnamed upper marl member) represent influxes of terrigenous material. The cause-effect relationships are uncertain (periodic rejuvenation of source areas?, vegetation changes?, climatic changes?, changes in depositional environment?).

6. The Whitestone Limestone Member of the Walnut and the Moffat mound of the Edwards are analogous high-energy carbonate deposits. Both formed barriers against terrigenous material coming from the north which favored formation of a considerable thickness of rudistid biostromes and pure miliolid limestone and chert facies of the Edwards to the south.

7. The Comanche Peak is transitional with the Edwards above and the Walnut below throughout the study area.

8. South of Moffat, Bell County, the Edwards progressively thickens and eventually makes up almost the entire Fredericksburg Division. In the southern and intermediate areas, studies of the Edwards are complicated by faulting and recrystallization. Nelson (1959, p. 80) suggested that recrystallization may be due, in part, to the absence of the Kiamichi in this area and attendant exposure of the Edwards to solution and weathering prior to Washita deposition.

9. The top of the Edwards is an undulatory surface commonly with abundant pholad borings. Young (1959, p. 758) reported that basal Washita biostratigraphic units onlap the Fredericksburg surface from north to south. West of Waco, Shelburne (1959, p. 118), Nelson (1959, p. 30), and Lozo (1959, p. 18) concurred in recognizing that the Kiamichi onlaps the Edwards surface from north to south. The present study supports the conclusion that the Edwards-Georgetown contact is unconformable.

10. The Fredericksburg Division in south-central Texas is a classic example of a physically defined time-stratigraphic unit of subseries rank, as emphasized by Hill (1937) and restated since by Lozo (1959).

The carbonate terminology and classification used in this study is taken from Folk (1959). This classification is well known and is not described here.

Numerous samples were collected from each measured section. These samples were studied with the aid of petrographic and binocular microscopes, using thin sections, polished and etched slabs, and hand specimens. The petrographic data were integrated in the measured section descriptions and were used to construct a petrographic grid. Distribution of the units of this grid is illustrated on lithotope maps (fig. 8).

Rocks of the Fredericksburg are divided into 12 facies, described below. The term facies, as used here, is meant to distinguish between different rock types and associated faunas. Representative thin sections for each facies are described in table 3 (in pocket). Thin section photomicrographs illustrating these facies are shown on Plates 10–15.

Facies Analysis

Intraclastic facies.—This facies consists of intraclasts in a spar or micrite matrix and is restricted to the Bull Creek Member of the Walnut in the eastern part of the southern and intermediate areas (fig. 8a, b). Fossils commonly associated with the facies are green algae, *Exogyra texana* Roemer, *Gryphaea mucronata* Gabb, *Trigonia*, other pelecypods, gastropods, echinoid plates, and miliolids. These forms are abundant throughout the facies.

There is a wide range of variation within this facies. The most common variant is the presence of pellets, rather than intraclasts, as the dominant allochem. The shape, size, and amount of the intraclasts that make up the majority of the allochems are also widely variable. There is generally less spar and fewer intraclasts in the intermediate area than to the north, but those intraclasts in the intermediate area are larger and are shades of red and brown (intraclasts in the other areas normally are cream or tan colored).

The intraclastic facies was deposited in a relatively high-energy, shallow marine environment. Judging by spatial configuration (fig. 8a, b) and petrography, this facies is a submarine bar-type deposit parallel to the shore, possibly analogous to the present Mustang Island along the Gulf Coast of Texas.

Intraclastic biomicrite facies.—This facies is a shell-fragment biomicrite containing 5 to 10 percent intraclasts with scattered pellets and glauconite grains. It is generally restricted to the Bull Creek Limestone Member of the Walnut in the southern, intermediate, and northern areas (fig. 8a, b). The main body of the facies is to the west of the intraclastic facies. The fauna of the intraclastic biomicrite facies is generally the same as for the intraclastic facies.

This facies is widely variable. The percentage, size, and type of intraclasts range between wide limits. The occurrence of pellets and glauconite is spotty and inconsistent. The percent and type of fossil fragments also vary inconsistently between measured sections.

These rocks seem to have been deposited in relatively quiet waters. However, enough energy was present to sweep some intraclasts into the lime mud from the intraclastic facies to the east. The water was probably shallow and relatively clear.

Quartz sand facies.—The quartz sand facies is composed of fine- to medium-grained quartz sand, clayey sand, and indurated sandstone flags. It is restricted to the Paluxy Sandstone in the northern area (fig. 8a). The facies contains few fossils; bone and oyster shell fragments were found in the upper part of the facies in the northern area. The major variation of the facies is in grain size, which ranges from fine silt to medium sand.

These rocks were deposited in a marginal continental to very near-shore marine environment.

Sandy biomicrite facies.—This facies is a shell-fragment biomicrite containing 1 to 10 percent silt and sand-sized quartz particles. It occurs in the northwestern edge of the Bull Creek Member (fig. 8a, b), generally parallel and close to the "feather edge" of the Bull Creek Member in the southern, intermediate, and northern areas. Fossils commonly associated with the facies are *Exogyra texana, Gryphaea mucronata, Inoceramus* prisms, other pelecypods, gastropods, echinoid plates, *Dictyoconus walnutensis*, miliolids, and green algae. Fossils occur in moderate amounts. The quartz grains in this facies range from very coarse sand to silt size. The amount of fossil frag-

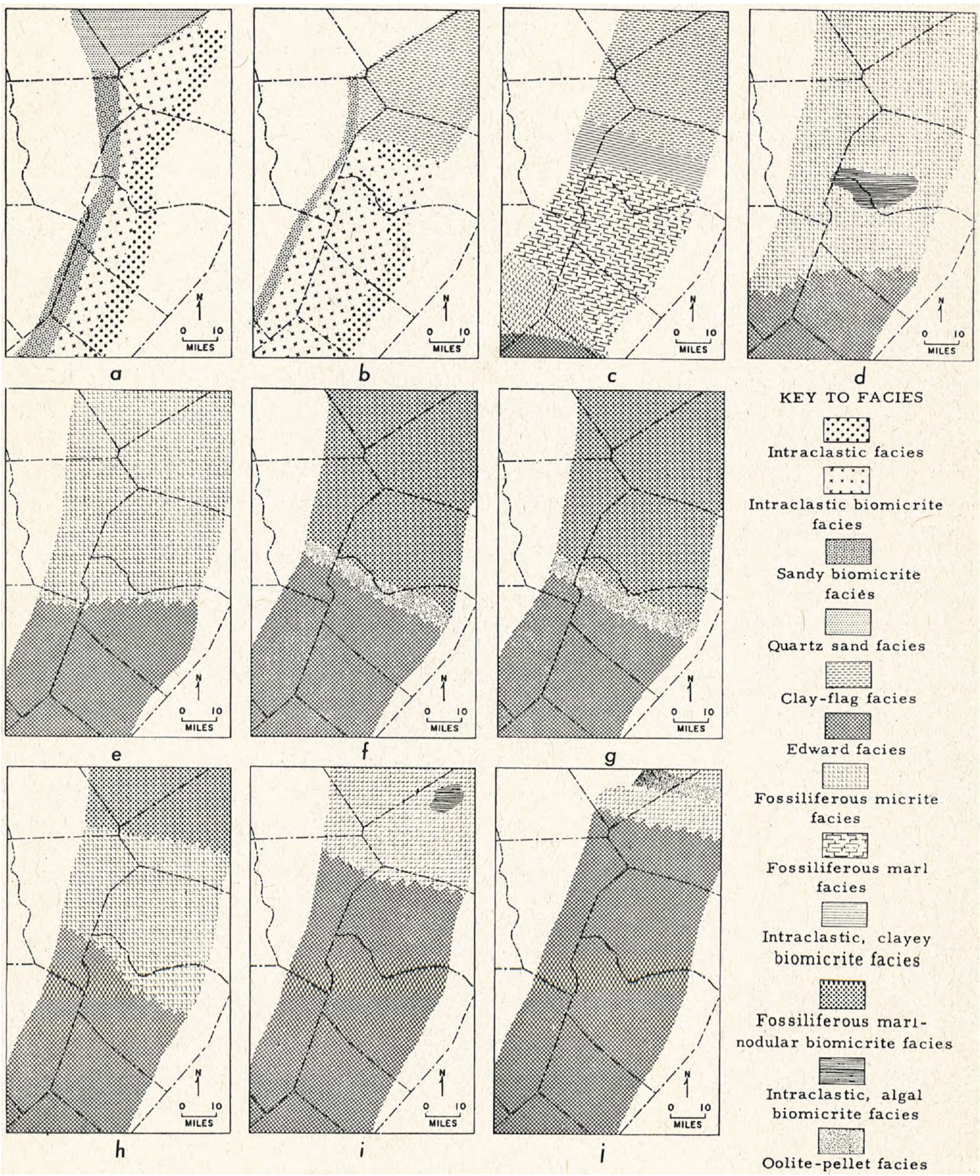


Fig. 8. Lithotope maps of the Fredericksburg Division.

ments in the biomicrite ranges from 10 to 40 percent. Some glauconite is present, especially in the southern area. In the intermediate area the facies may develop into sandy beach-type carbonate deposits with cross-bedding and local sparry cement.

This facies was deposited in shallow marine and locally agitated water. An influx of coarse terrigenous material came from the west and north. Local areas of cross-bedded spar are probably beach or very near-shore deposits.

Clay-flag facies.—The clay-flag facies consists of brown, fossiliferous, calcareous clay with scattered ripple-marked oyster biomicrite flagstones. The facies occurs in the Bee Cave Member of the Walnut in the northern area (fig. 8b, c). Fossils normally associated with the facies are *Exogyra texana, Gryphaea mucronata,* pelecypods, and gastropods.

The only major variation in this facies is an increased number of biosparite flags in southern Coryell County overlying highs on the top of the Paluxy. There are various local areas of more sparry flags in Bell County, but they follow no consistent pattern.

These rocks were deposited in a shallow marine to near-shore, salt-marsh environment, filled with fine terrigenous material. The biomicrite flags represent either local areas protected from terrigenous material or periods of local agitated conditions which carried clay to other parts of the shelf.

Intraclastic, clayey biomicrite facies.—This facies consists of clayey, intraclastic biomicrite to fossiliferous micrite. It is concentrated in the intermediate area within the Bee Cave Member of the Walnut (fig. 8c). Fossils commonly associated with the facies are *Exogyra texana,* scattered *Gryphaea mucronata,* other pelecypods, gastropods, and rarely *Metengonoceras* sp. Fossils are scattered and not as profuse as in the fossiliferous marl facies of the Bee Cave Member in the southern area. This facies is more nodular and contains less clay and more lime than its northern and southern equivalents.

The distribution of intraclasts within the facies is irregular, being concentrated in one spot and absent in others. The amount of allochems ranges from 10 to 40 percent or more. Most shell fragments are rounded.

The facies was deposited in muddy, shallow marine water. Periodic agitation formed intraclasts and rounded the shell fragments. Circulation in the area may have been somewhat restricted judging by the large amounts of pyrite present. This facies may have acted as a barrier against terrigenous material coming from the north.

Fossiliferous marl[6] *facies.*—The fossiliferous marl facies is composed of clayey biomicrite or marl. The clay content of the marl is generally 30 percent by weight with 15 to 20 percent fossil fragments. The facies is restricted to the Bee Cave Member of the Walnut in the southern area (fig. 8c). Fossils normally associated with the facies are *Exogyra texana, Gryphaea mucronata,* other pelecypods, gastropods, *Metengonoceras* sp., and echinoids.

The facies contains less clay in the southeast than to the north, with an attendant increase in nodular biomicrite interbeds to the south.

The rocks of the fossiliferous marl facies were deposited in a marine marsh to mudflat environment. The northern equivalent of this facies (fig. 8c), the clay-flag facies, was deposited in a similar environment, with less lime and perhaps more local agitation. The clay in the fossiliferous marl facies is illite-kaolinite, the clay of the clay-flag facies is montmorillonite-kaolinite. It is postulated that the clay of the fossiliferous marl facies (illite-kaolinite) is of local origin, probably from the Llano region, and the clay of the clay-flag facies (montmorillonite-kaolinite) was probably swept in from the north or northwest.

[6] Marl, as used in this paper, is a carbonate rock containing enough clay to form a marked recessive slope in the weathering profile.

Fossiliferous micrite facies.—This facies, nodular fossiliferous micrite, occurs in the Comanche Peak Limestone and the Cedar Park Limestone Member of the Walnut Formation in the southern, intermediate, and northern areas (fig. 8d-j). Fossils commonly associated with the facies are green algae, *Exogyra texana*, *Gryphaea mucronata*, other pelecypods, gastropods, *Metengonoceras* sp., and *Dictyoconus walnutensis*. All the fossils are scattered and normally make up 5 percent or less of the rock. Shell fragments are all very small and randomly oriented. This lack of orientation and the fine size are probably a result of burrowing activity of organisms.

Algae are more abundant in the fossiliferous micrite in the Cedar Park than in the Comanche Peak. The composition of this facies is very constant throughout the area of study.

The facies was deposited in quiet, well-lighted, shallow marine water. Little or no terrigenous material was deposited in this environment. This facies may represent a slightly deeper, less restricted environment than any of the facies mentioned previously.

Intraclastic, algal biomicrite facies.—This facies occurs in restricted portions of the intermediate and northern areas (fig. 8d, j) associated with the Comanche Peak Limestone and Cedar Park Member of the Walnut. Fossils commonly associated with the facies are green algae, *Gryphaea mucronata*, *Pinna* sp., and other molluscan fragments.

The intraclastic, algal biomicrite facies in the Comanche Peak Limestone of the northern area contains corals and pebble-size intraclasts but otherwise is identical in the two separate occurrences.

This facies might be called the "preoolite" facies because it occurs in the areas under and immediately adjacent to the development of the Whitestone Limestone Member and Moffat mound in Williamson and Bell counties, respectively. It was deposited in well-lighted, aerated, agitated, marine water. The agitation increased during latter stages of deposition. The distribution of the facies was possibly controlled by sea-floor topography.

Fossiliferous marl—nodular biomicrite facies.—This facies consists of interbedded nodular biomicrite and fossiliferous marl with concentration of *Gryphaea mucronata* in large banks or lumachelles. The facies makes up the entire Keys Valley and upper marl units of the Walnut Formation and is restricted to the intermediate and northern areas (fig. 8f-h). A single thin section is insufficient to describe the characteristics of this variable facies. The reader is referred to the measured sections (Pls. 17–19, in pocket) for a detailed description of this facies and its many variants and to figures 9–12 for location of the sections. Fossils commonly associated with the facies are *Exogyra texana*, *Gryphaea mucronata*, other pelecypods, gastropods, *Oxytropidoceras* sp., *Metengonoceras* sp., *Enallaster* sp., and solitary corals.

These rocks were deposited in an environment that alternated between saltwater marsh and more open marine conditions. The *Gryphaea* lumachelles possibly represent brackish conditions transgressing over a wide area in a short time.

Oolite-pellet facies.—The oolite-pellet facies is composed of oosparite and pelsparite with associated intraclasts and fossils. It is generally found in the Edwards Limestone and Walnut Formation as mounds with a general northwest trend (fig. 8f, g, j). Fossils normally associated with the facies are *Trigonia* sp. (southern area), rudistid fragments, other molluscan fragments, green algae, and miliolids.

The most significant variation in this facies is the amount of pellets, oolites, and intraclasts at or between any particular localities. More pellets are present in the southern area and more oolites and intraclasts occur in the northern area. The oolites in the northern area are more symmetrical and larger than those in the southern area.

These rocks were deposited in highly agitated, relatively clear, shallow marine water. They form lenticular, bar-shaped deposits which effectively blocked the passage of terrigenous material to the south.

Edwards facies.—The Edwards facies is a composite of several limestone types: rudistid limestone, miliolid biomicrite and biosparite, rudistid shell-fragment biomicrite, nodular chert, and various rock types resulting from post-depositional recrystallization phenomena. However, in the study area it is very poorly exposed and extensively recrystallized, and the distribution and relationships of the various limestone types were not determined. The reader is referred to Nelson (1959) for description and illustration of the petrography of these rock types and their significance in the region north of the study area.

Facies Distribution

The distribution of the facies described in the preceding section is outlined in figures 6–8.

Lithotope maps (fig. 8) show the horizontal distribution of the facies through time. It cannot be emphasized too strongly that these distributional patterns are drawn upon planes that are presumed to be synchronous. However, it is evident that a series of 10 synchronous lines could not be drawn through such a body of rock as the Fredericksburg with any degree of certainty. It is the writer's belief, however, that the depositional patterns developed by the use of such maps are, in general, valid and give a gross picture of the depositional framework.

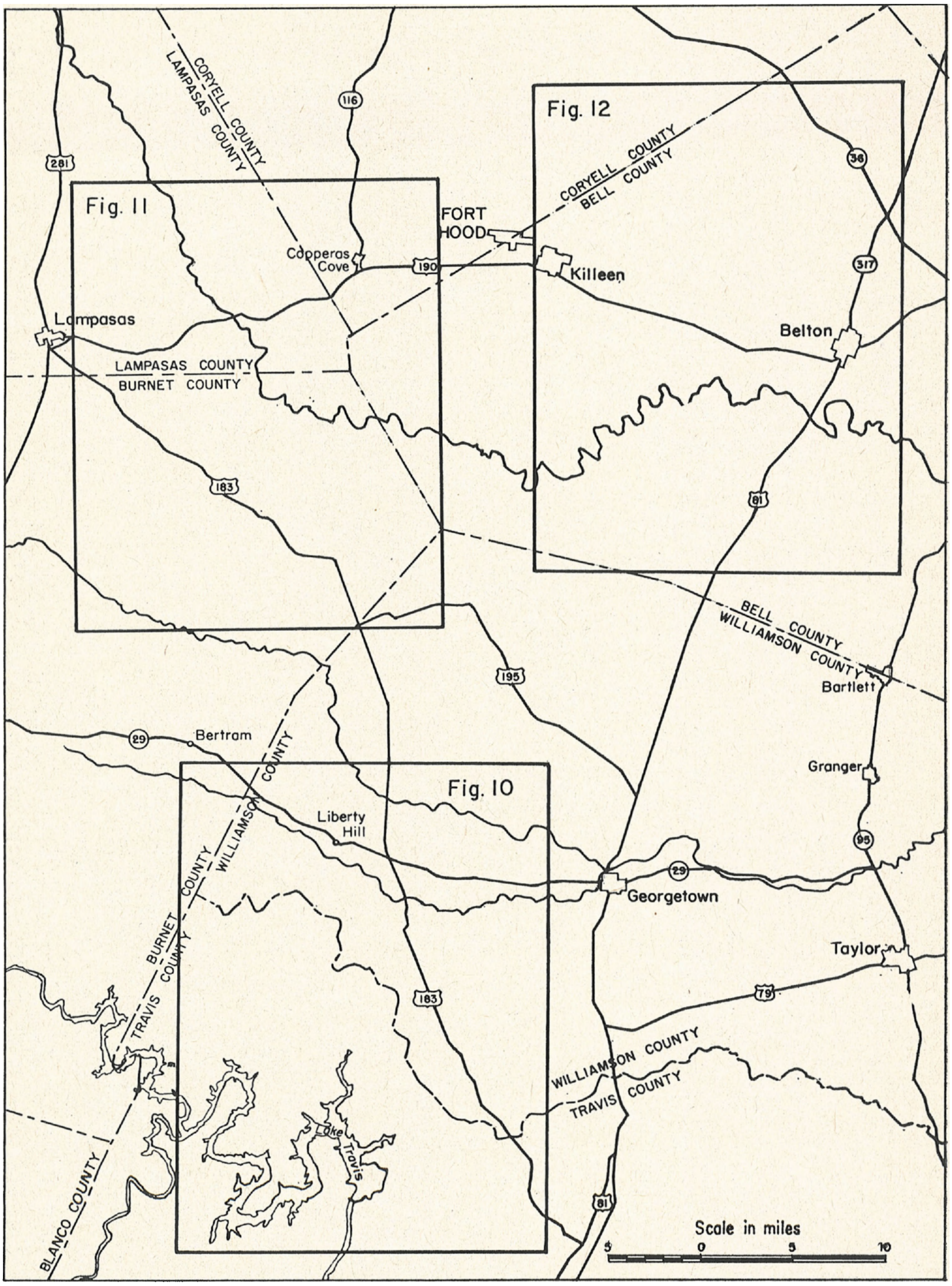


FIG. 9. Outline map showing location maps of measured sections.

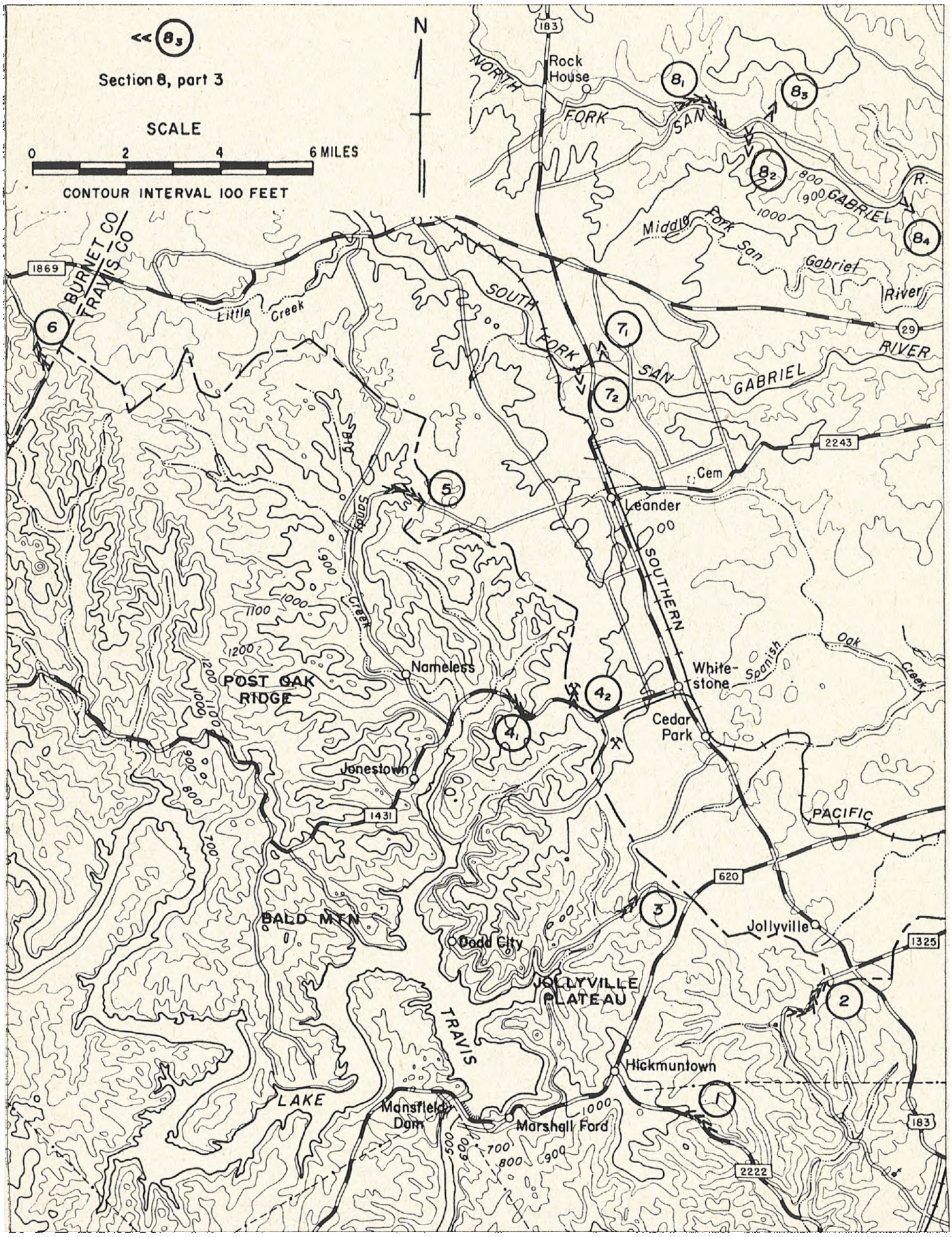


FIG. 10. Map showing location of measured sections 1–8 (Pl. 17).

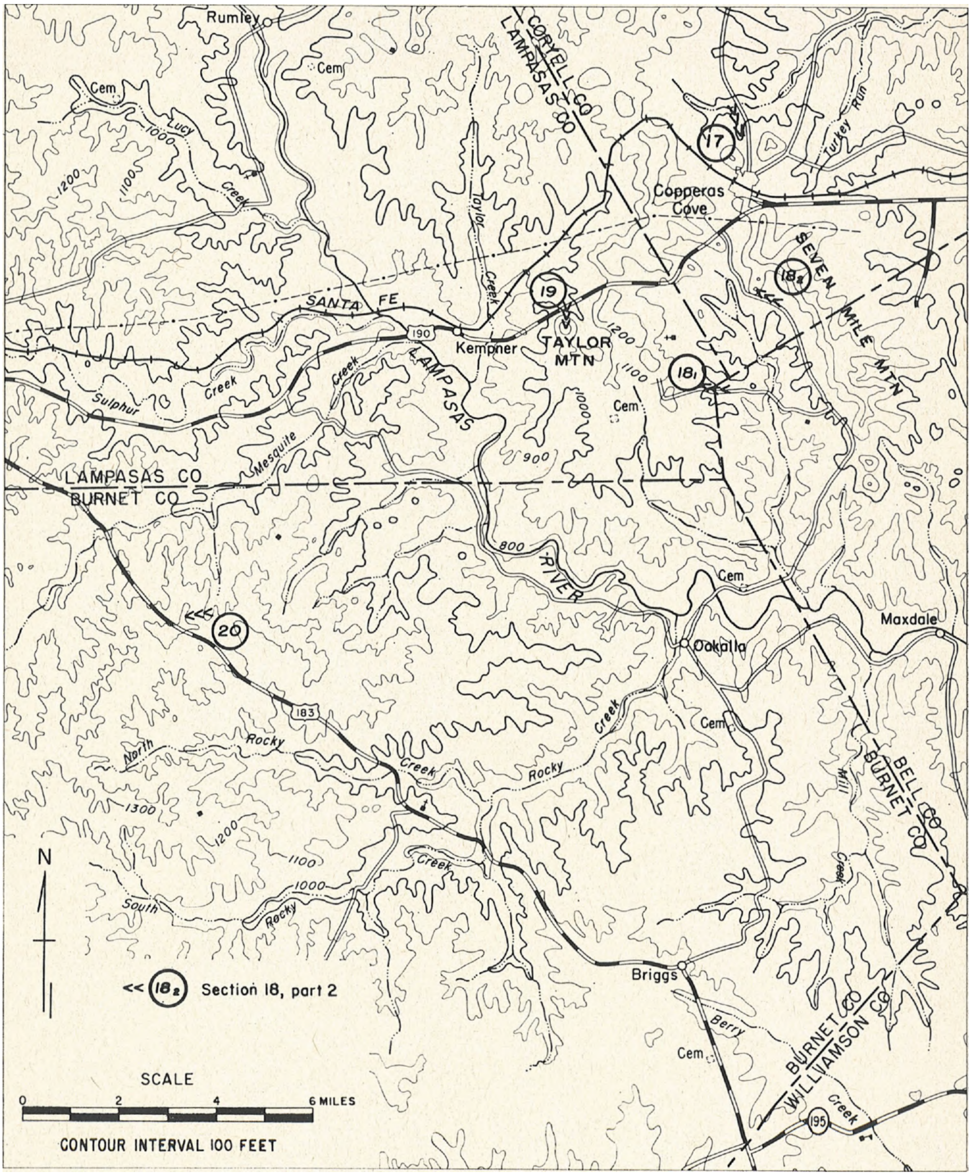


FIG. 11. Map showing location of measured sections 17–20 (Pl. 19).

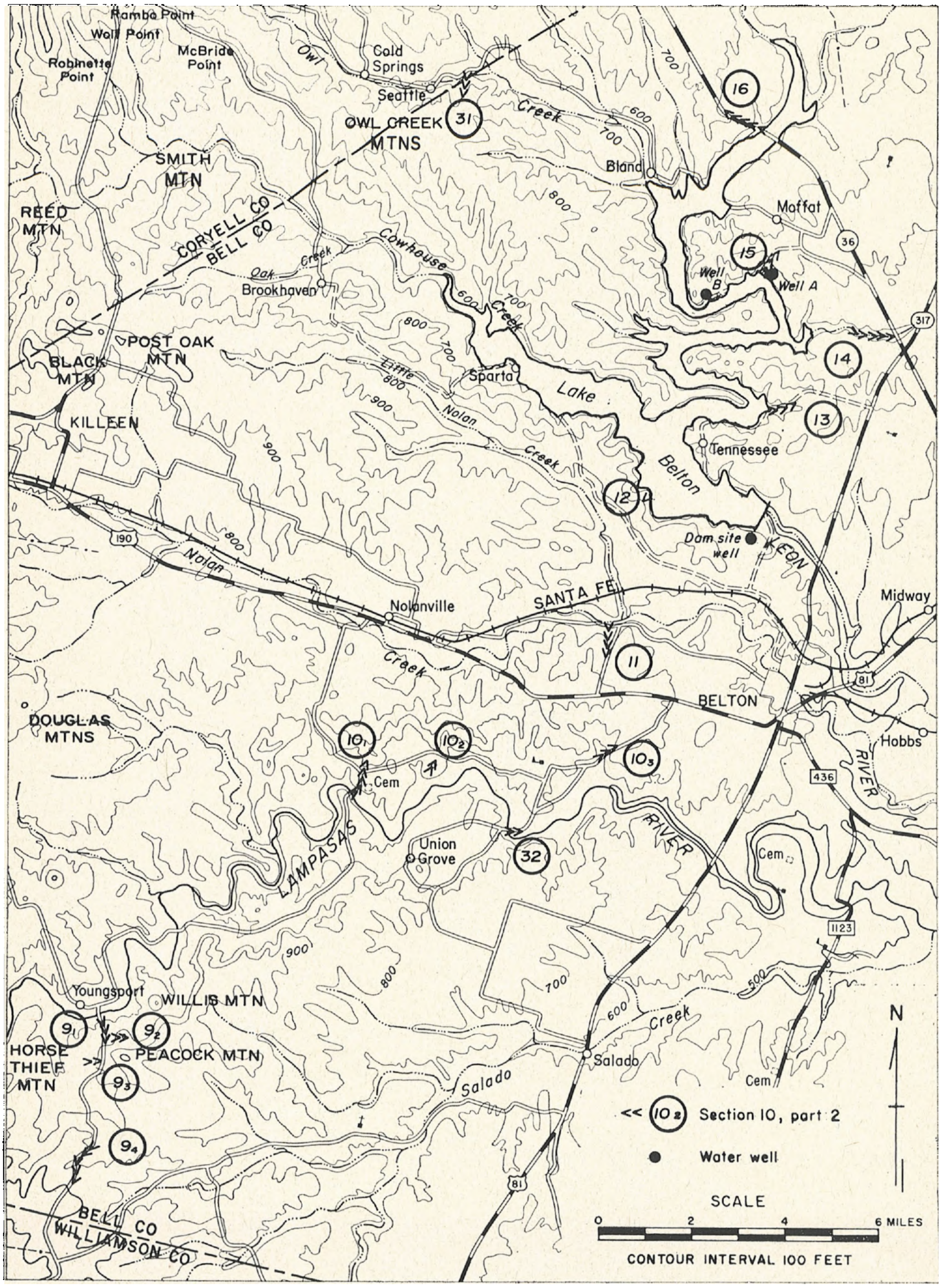


FIG. 12. Map showing location of measured sections 9–16, 31, and 32 (Pls. 18, 19). Section 32 is the type section of the Keys Valley Marl Member of the Walnut Formation.

GEOLOGIC HISTORY

The Fredericksburg rocks described in this paper are a carbonate shelf sequence which was deposited in shallow water on the slowly subsiding west flank of the Tyler basin. The Fredericksburg is the middle cycle of three distinct, genetically related cycles of sedimentation comprising the Comanche Cretaceous in central Texas. Within the Fredericksburg Division, a cyclic sequence of events is manifest on the southern part of the shelf. These events are as follows:

1. The top surface of the Trinity was subaerially exposed.
2. The basal clastic Fredericksburg limestone (Bull Creek Limestone Member of the Walnut Formation) onlapped this surface to the north and northwest. This clastic limestone sequence forms the analogue of the Paluxy continental to near-shore terrigenous sequence to the north (fig. 8a, b).
3. A clay-lime mud wedge (Bee Cave Marl Member of the Walnut Formation) was deposited in a marine marsh environment which moved from north to south, blanketing the initial clastic limestones (fig. 8c).
4. A lime mud blanket deposit (Cedar Park Limestone Member of the Walnut Formation) rapidly filled and covered the marsh environments (fig. 8d).
5. The northern part of this lime mud blanket was exposed subaerially while deposition continued to the south (fig. 8d).
6. A clay-lime wedge (Keys Valley Marl Member of the Walnut Formation) of alternating marine marsh and more open marine environments moved from north to south covering the entire surface of the lime mud blanket. This wedge was restricted by the development of an oolite bar at the juncture of the southern and intermediate areas (fig. 8e, f).
7. This clay-lime wedge was progressively covered by a lime mud blanket, the Comanche Peak Limestone, transgressing from south to north (fig. 8g).
8. The Comanche Peak was, in turn, followed by the Edwards facies moving from south to north (fig. 8h).
9. This south-to-north transgression (which is apparent because the sections are parallel to the depositional dip) of the Comanche Peak and Edwards facies was interrupted by the development of an oolite lentil trending northwestward in Bell County (fig. 8j).
10. The top of the Fredericksburg was subaerially exposed.
11. This surface was covered by basal Washita sediments transgressing from north to south.

REFERENCES

ADKINS, W. S. (1933) The Mesozoic systems in Texas, *in* The geology of Texas, Vol. I, Stratigraphy: Univ. Texas Bull. 3232 (Aug. 22, 1932), pt. 2, pp. 239–518.

———, and ARICK, M. B. (1930) Geology of Bell County, Texas: Univ. Texas Bull. 3016, 92 pp.

AMERICAN COMMISSION ON STRATIGRAPHIC NOMENCLATURE (1961) Code of stratigraphic nomenclature: Bull. Amer. Assoc. Petrol. Geol., vol. 45, pp. 645–665.

FOLK, R. L. (1959) Practical petrographic classification of limestones: Bull. Amer. Assoc. Petrol. Geol., vol. 43, pp. 1–38.

HILL, R. T. (1889) Check list of the invertebrate fossils from the Cretaceous formations of Texas, accompanied by notes on their geographic and geologic distribution, Pt. 1: Univ. Texas, School of Geol. Bull. IV, xxxi, 16 pp.

——— (1891) The Comanche series of the Texas-Arkansas region: Bull. Geol. Soc. Amer., vol. 2, pp. 503–523.

——— (1901) Geography and geology of the Black and Grand Prairies, Texas: U. S. Geol. Survey 21st Ann. Rept., pt. 7, 666 pp.

——— (1937) Paluxy sands, with further notes on the Comanche Series (abst.): Geol. Soc. Amer. Proc. 1936, pp. 79–80.

———, and VAUGHN, T. W. (1898a) Description of the Nueces quadrangle: U. S. Geol. Survey Geol. Atlas, Nueces Folio (no. 42), 4 pp.

———, and ——— (1898b) Geology of the Edwards Plateau and Rio Grande Plain adjacent to Austin and San Antonio, Texas, with reference to the occurrence of underground waters: U. S. Geol. Survey 18th Ann. Rept., pt. 2, pp. 193–321.

HORNE, S. W. (1930) The stratigraphy of the Walnut Formation in Lampasas, Williamson, Travis, Hays, and Comal counties: Univ. Texas Master's thesis, 41 pp.

IKINS, W. C. (1941) Stratigraphy and paleontology of the Walnut and Comanche Peak Formations: Univ. Texas Ph.D. dissertation, 180 pp.

——— (1949) Stratigraphy and paleontology of the Walnut and Comanche Peak Formations: Shreveport Geol. Soc. Guidebook, 17th Ann. Field Trip (Cretaceous of Austin, Texas, area), pp. 65–84.

LOZO, F. E. (1949) Stratigraphic relations of Fredericksburg limestones, north-central Texas: Shreveport Geol. Soc. Guidebook, 17th Ann. Field Trip (Cretaceous of Austin, Texas, area), pp. 85–91.

——— (1959) Stratigraphic relations of the Edwards Limestone and associated formations in north-central Texas, *in* Symposium on Edwards Limestone in central Texas: Univ. Texas Pub. 5905, pp. 1-19.

———, and STRICKLIN, F. L., Jr. (1956) Stratigraphic notes on the outcrop basal Cretaceous, central Texas: Trans., Gulf Coast Assoc. Geol. Soc., vol. 6, pp. 67–78.

MOORE, C. H. (1959) Stratigraphy of the Walnut formation, south-central Texas: Univ. Texas Master's thesis, 109 pp.

——— (1961) Stratigraphy of the Walnut Formation, south-central Texas: Texas Jour. Sci., vol. 13, no. 1, pp. 17–40.

MURRAY, G. E. (1961) Geology of the Atlantic and Gulf Coastal Province of North America: Harper and Brothers, New York, 629 pp.

NELSON, H. F. (1959) Deposition and alteration of the Edwards Limestone, central Texas, *in* Symposium on Edwards Limestone in central Texas: Univ. Texas Pub. 5905, pp. 21–85.

PERKINS, B. F. (1960) Biostratigraphy of Comanche Series, northern Mexico and Texas: Geol. Soc. Amer., Mem. 83, 138 pp.

PHLEGER, F. B. (1960) Ecology and distribution of recent foraminifera: Johns Hopkins Press, Baltimore, 348 pp.

SHELBURNE, O. B. (1959) Stratigraphic study of the Kiamichi Formation in central Texas, *in* Symposium on Edwards Limestone in central Texas: Univ. Texas Pub. 5905, pp. 105–130.

SHREVEPORT GEOLOGICAL SOCIETY (1949) Guidebook, 17th Ann. Field Trip (Cretaceous of Austin, Texas, area), 109 pp.

SHUMARD, B. F. (1860) Observations upon the Cretaceous strata of Texas: St. Louis Acad. Sci. Trans., vol. 1, pp. 583–588.

TAFF, J. A. (1892) Reports on the Cretaceous area north of the Colorado River: Texas Geol. Surv. 3rd Ann. Rept. (1891), pp. 267–379.

TEXAS ALMANAC (1961–1962) of the Dallas Morning News: A. H. Belo Corp., Dallas, 704 pp.

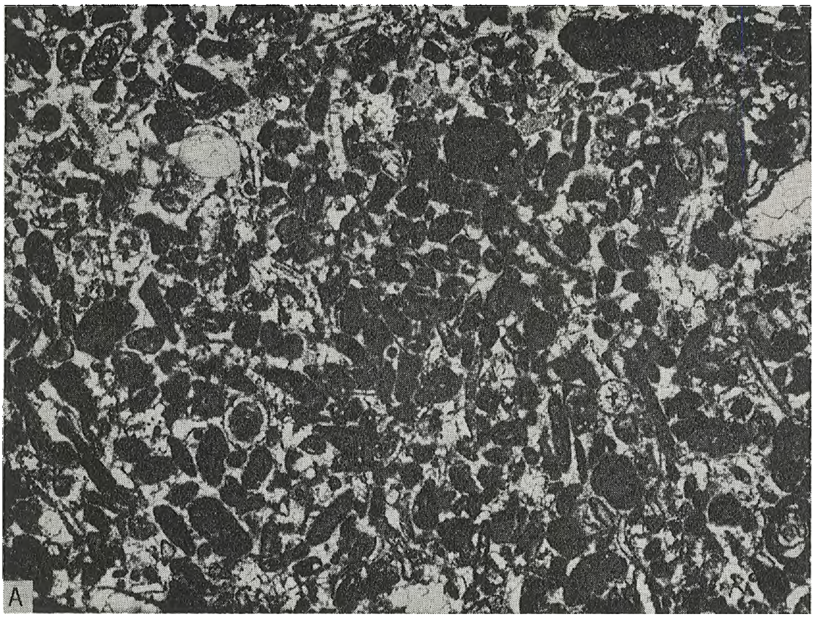
WALL, E. L. (1955) Stone of the ages: Texas Parade, vol. 16, no. 6, pp. 18–22.

WINTON, W. M. (1925) The geology of Denton County: Univ. Texas Bull. 2544, 86 pp.

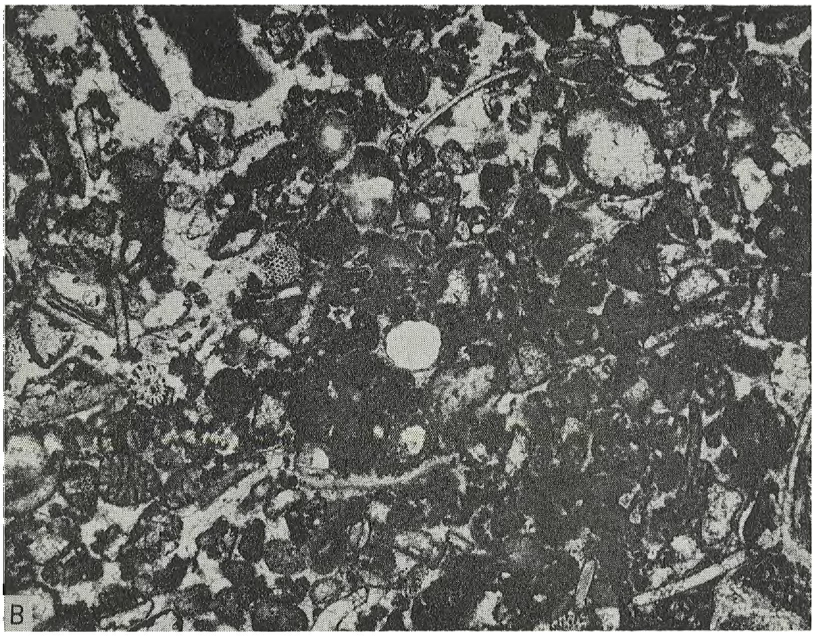
YOUNG, K. P. (1959) Techniques of mollusc zonation in Texas Cretaceous: Amer. Jour. Sci., vol. 257, pp. 752–769.

Plates 10–15

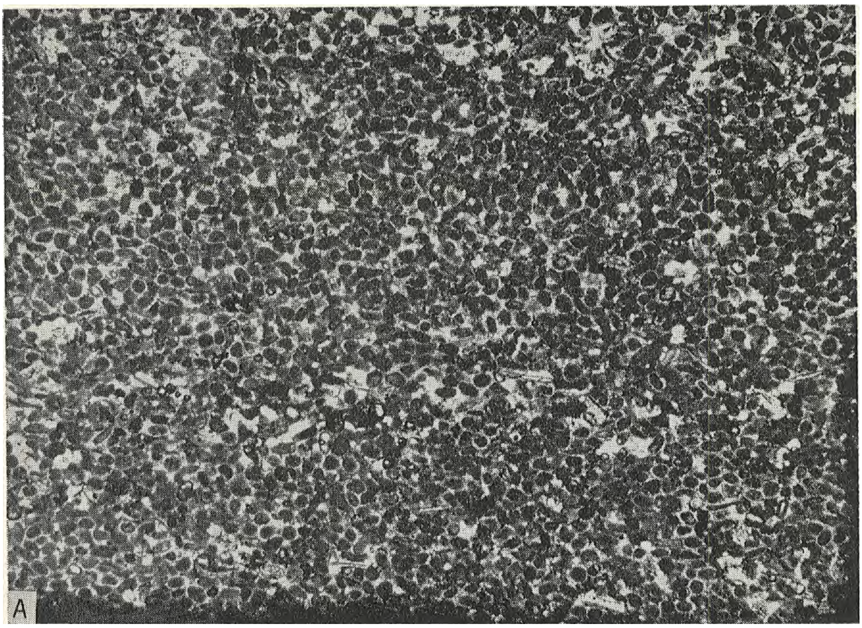
Thin Section Photomicrographs



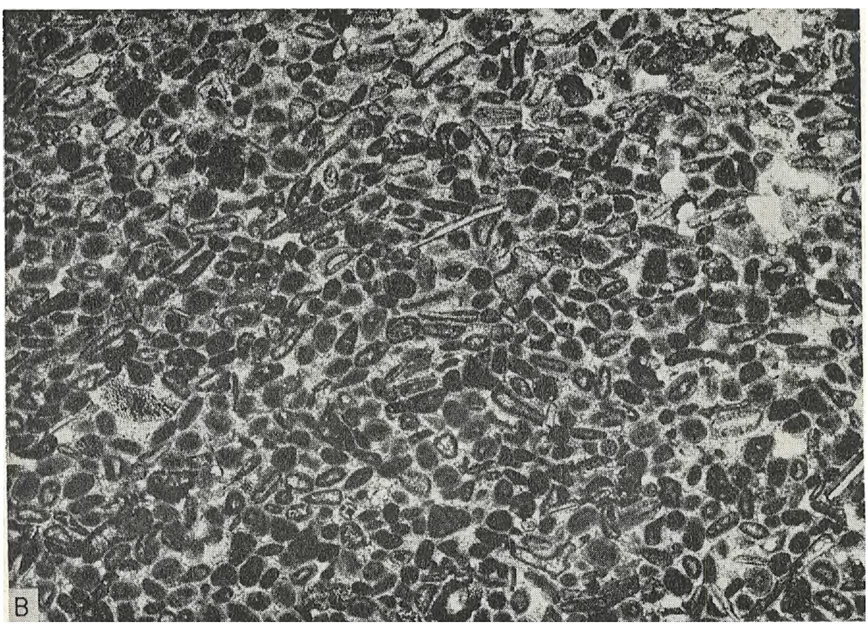
(A) Fossiliferous intrasparite. From 4 feet below the top of the Bull Creek Limestone Member of the Walnut Formation at Wimberly, Hays County, Texas. Sample WI-124, x18.



(B) Pelletal biosparite. Edwards Limestone, Moffat section (no. 15, Pl. 19), Bell County, Texas. Sample M-14, x24.



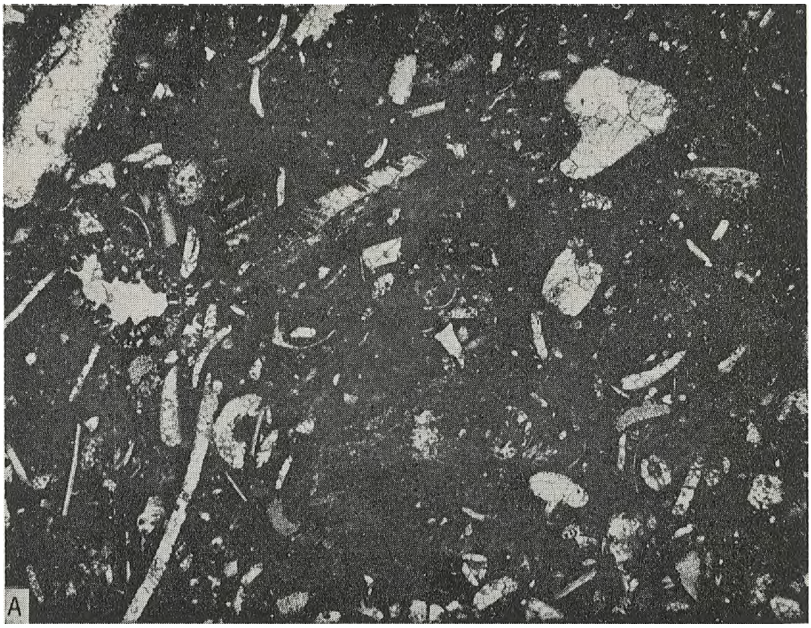
(A) Fossiliferous pelsparite. Whitestone Limestone Member of the Walnut Formation, Whitestone section (no. 4, Pl. 17), Williamson County, Texas. Sample WSI-14, x24.



(B) Pelletal, fossiliferous oosparite. Whitestone Limestone Member of the Walnut Formation, Whitestone section (no. 4, Pl. 17), Travis County, Texas. Sample WSII-4, x24.

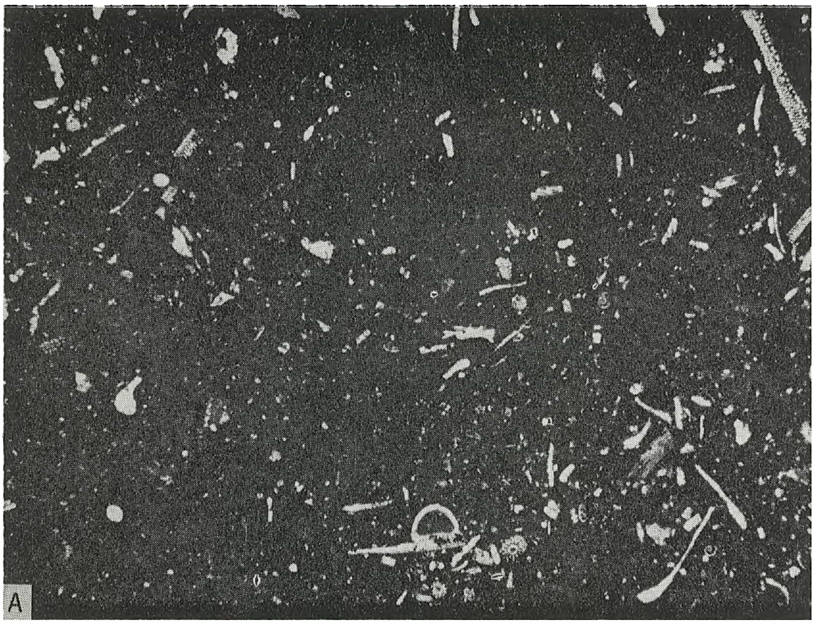
(A) Clayey biomicrite. From 12 feet above the base of the Bee Cave Marl Member of the Walnut Formation, along the Bee Cave Road (Farm Road 2244), just west of Austin, Travis County, Texas. Section 2 of Moore (1961). Sample BE-12, x18.

(B) Clayey, intraclastic biomicrite. Bee Cave Marl Member of the Walnut Formation, North San Gabriel section (no. 8, Pl. 17), Williamson County, Texas. Sample NSGII-10, x12.



(A) Intraclastic, algal biomicrite. Cedar Park Limestone Member of the Walnut Formation, Bagdad-Leander section (no. 5, Pl. 17), Travis County, Texas. Sample BL-19, x18.

(B) Shell-fragment biomicrite. Bee Cave Marl Member of the Walnut Formation, Southwest Belton section (no. 9, Pl. 18), Bell County, Texas. Sample HMl-5, x12.



(A) Fossiliferous micrite. Comanche Peak Limestone, North San Gabriel section (no. 8, Pl. 17), Williamson County, Texas. Sample NSGI-5, x18.

(B) Sandy biomicrite (under cross nicols). Bull Creek Limestone Member of the Walnut Formation, Bagdad-Leander section (no. 5, Pl. 17), Travis County, Texas. Sample BLI-1, x18.

Calcareous, fine-grained quartz sandstone (under cross nicols). From approximately 5 feet above the base of the Paluxy Sandstone near Pinyan Creek, southeast of Bertram, Burnet County, Texas. Sample P-2, x36.

Index

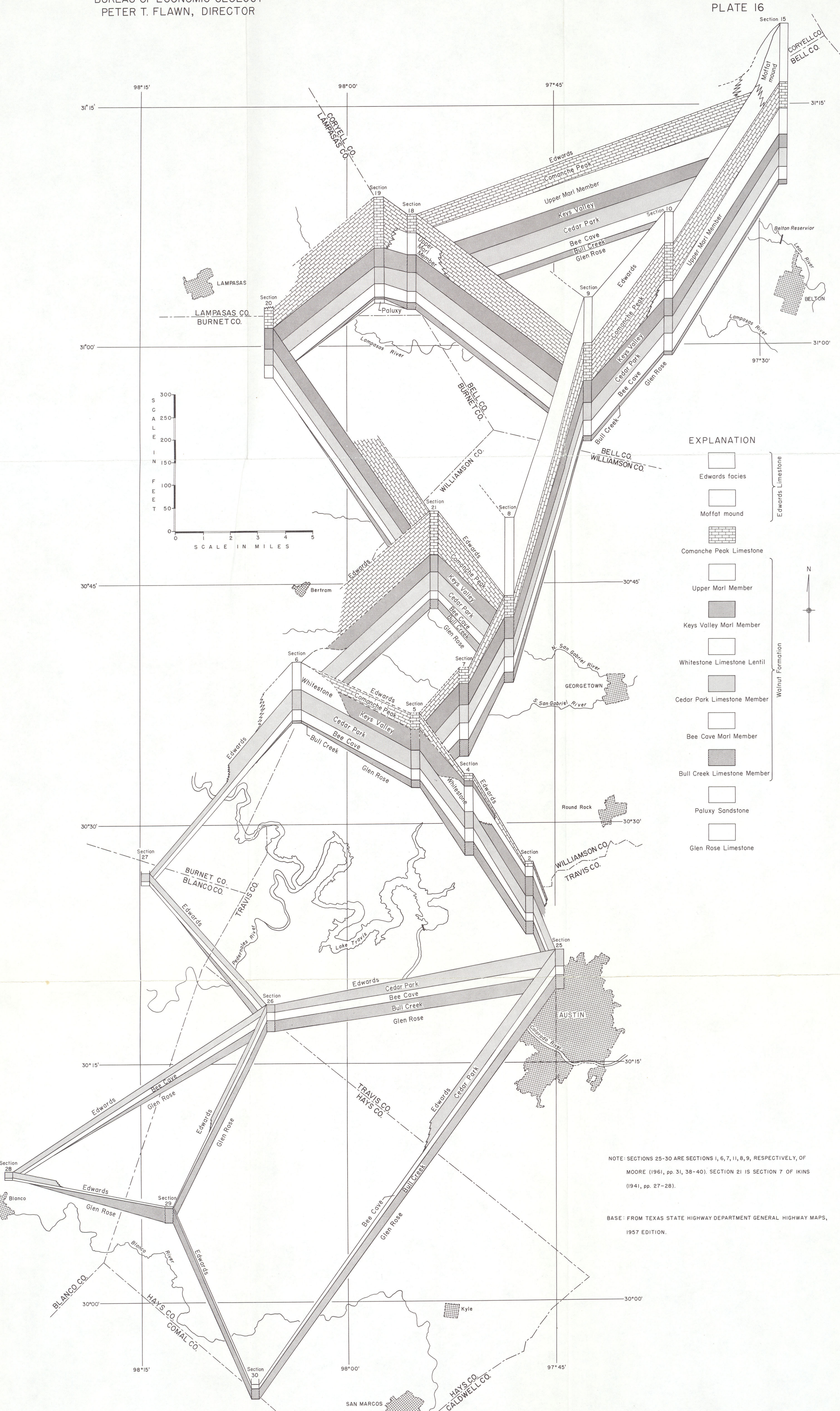
Table 3. Petrographic descriptions of thin sections chosen as typical of each Fredericksburg facies.

SAMPLE NUMBER (Stratigraphic position of sample indicated on section)	SECTION NUMBER (Plates 17 and 18)	ROCK NAME	ORTHOCHEMS			ALLOCHEMS																					TERRIGENOUS CONSTITUENTS						ALLOCHEM SORTING	AVG. ALLOCHEM GRAIN SIZE mm	Loose > 50% matrix Medium 25-50% matrix Tight < 25% matrix
							FOSSILS														INTRACLASTS		PELLETS		OOLITES			QUARTZ			CLAY				
								OYSTERS			OTHER MOLLUSCS			FORAMINIFERA		ECHINOIDS			ALGAE																
			Total %	Micrite %	Spar %	Total %	Total	%	Size mm	Shape	%	Size mm	Shape	%	Size mm	%	Size mm	Shape	%	Size mm	Total %	Size mm	Total %	Size mm	Total %	Size mm	Total %	%	Size	Shape	%	Distribution			
CM-8	10	Intraclastic, shell fragment biomicrite	75	98	2	22	15	26	1.0	Ang.	40	0.5	Ang.	tr	0.3	20	0.5	Ang.	14	0 3	7	1 0	-	-	-	-	3	100	0.15	Ang.	-	-	Poor	0.4	Loose
BL-1	5	Sandy, shell fragment biomicrite	82	98	2	10	10	-	-	-	80	1.0	Ang	-	-	tr	0.5	Ang	20	0.3	-	-	-	-	-	-	8	100	0.2	Ang.	-	-	Poor	0.8	Loose
HMI-5	10	Shell fragment biomicrite	46	100	-	54	54	37	5-10	Ang	51	5-10	Ang.	-	-	12	0.5	Ang.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Poor	5-10	Medium
NSGII-10	8	Intraclastic biomicrite	64	100	-	36	18	24	2.0	Rnd	tr	0.5	Rnd.	-	-	66	0.5	Rnd.	-	-	18	1.5	-	-	-	-	tr	100	0.1	Ang	-	-	Poor	1.0	Loose
NSGI-5	8	Fossiliferous micrite	94	100	-	6	6	tr	1 0	Ang	23	0.5	Ang.	-	-	77	0.5	Ang.	tr	0.2	-	-	-	-	-	-	tr	100	0.1	Ang	-	-	Poor	0 5	Loose
BL-19	5	Algal biomicrite	73	100	-	27	25	4	1.0	Ang	36	1 0	Ang.	-	-	8	0.5	Ang.	52	0 5	1	0.8	1	0 2	-	-	-	-	-	-	-	-	Poor	0.8	Loose
WSII-4	4	Fossiliferous, pellet oospar	34	-	100	66	16	12	0.5	Rnd	62	0.4-0 5	Rnd.	-	-	12	0 3	Rnd.	14	0.3	-	-	22	0.3	28	0.3	-	-	-	-	-	-	Very good	0.3	Medium
CP-129	*	Fossiliferous intrasparite	42	16	26	58	15	-	-	-	14	0.4	Ang.	66	0.25	20	0.35	Rnd	-	-	43	0.35	-	-	-	-	-	-	-	-	-	-	Good to poor	0.3	Medium
BE-9	**	Clayey biomicrite	52	96	4	18	16	43	0 2	Ang	25	0.4	Ang	-	-	13	0 2	Ang	19	0.3	2	0.3	-	-	-	-	30	-	-	-	100	Mixed with micrite	Fair	0 3	Loose

*Sample from Bull Creek Limestone Member of the Walnut Formation 12 feet above the Glen Rose Limestone on City Park road just northwest of Austin, Travis County (Moore, 1961, p. 23).

**Sample from the Bee Cave Marl Member of the Walnut Formation 9 feet above the base of the Bee Cave, along Bee Cave road just west of Austin, Travis County (Moore, 1961, p 29)

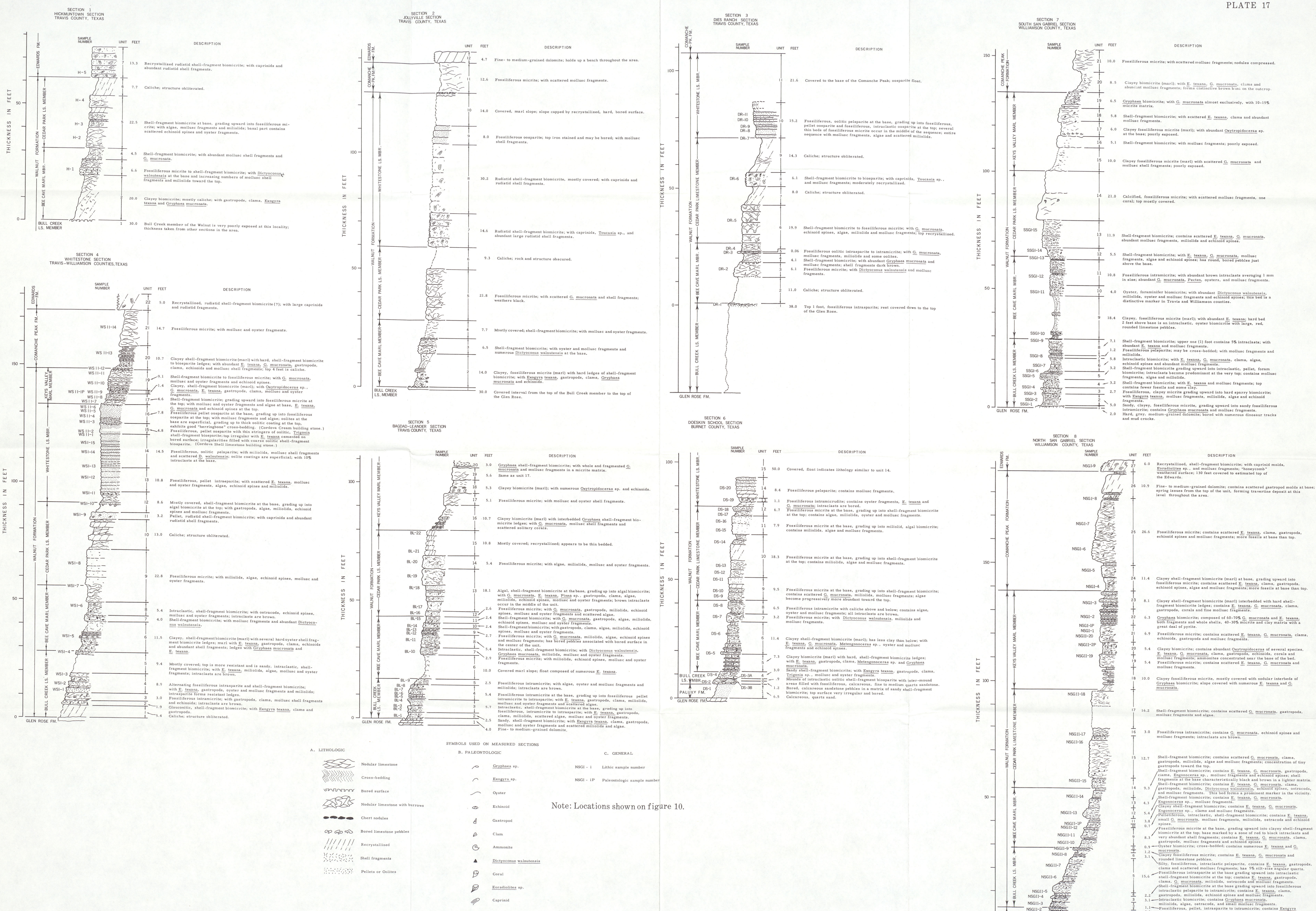
THE UNIVERSITY OF TEXAS
BUREAU OF ECONOMIC GEOLOGY
PETER T. FLAWN, DIRECTOR



NOTE: SECTIONS 25-30 ARE SECTIONS 1, 6, 7, 11, 8, 9, RESPECTIVELY, OF MOORE (1961, pp. 31, 38-40). SECTION 21 IS SECTION 7 OF IKINS (1941, pp. 27-28).

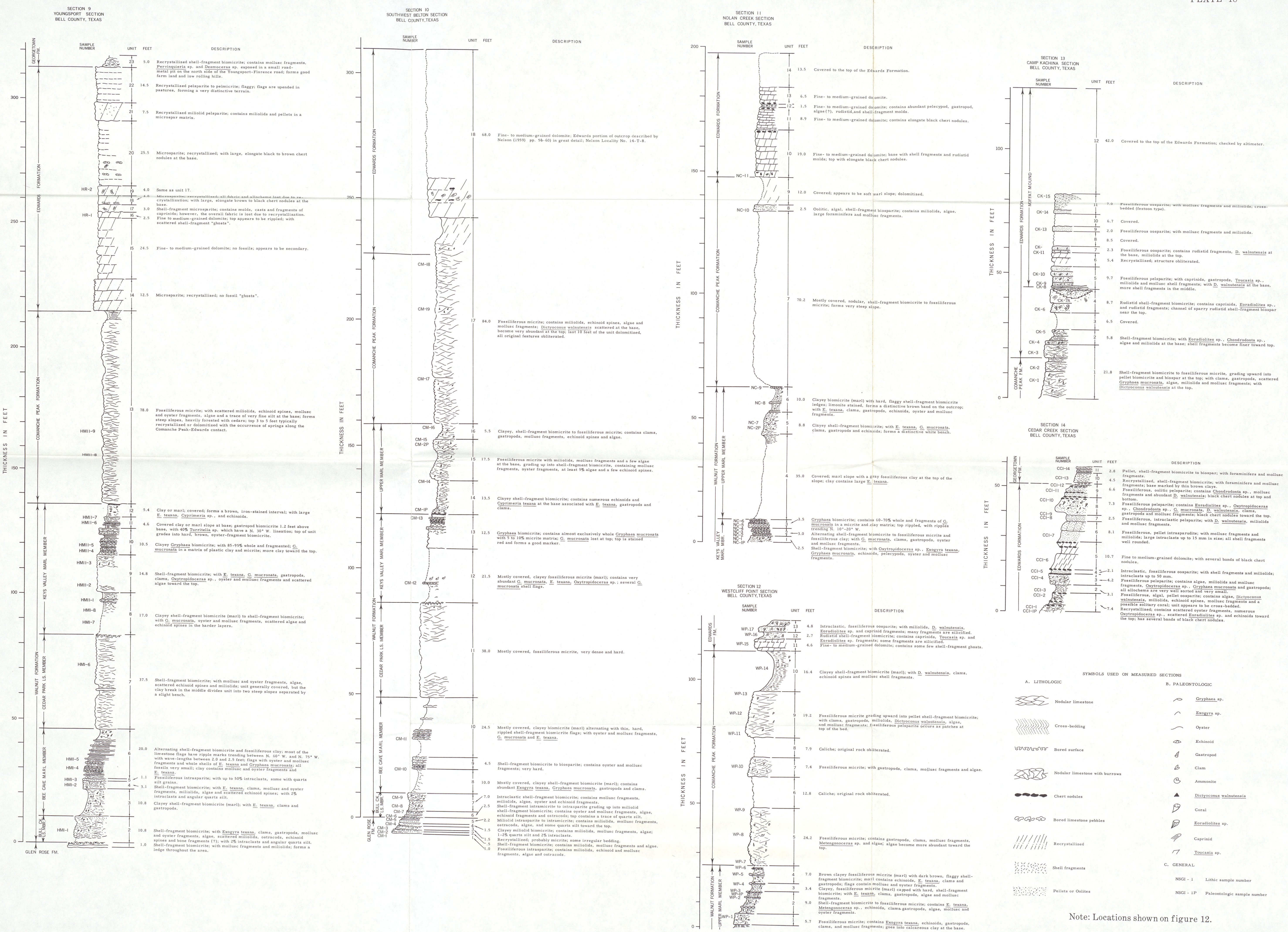
BASE: FROM TEXAS STATE HIGHWAY DEPARTMENT GENERAL HIGHWAY MAPS, 1957 EDITION.

STEREOGRAM OF THE FREDERICKSBURG DIVISION IN SOUTH-CENTRAL TEXAS



Note: Locations shown on figure 10.

MEASURED SECTIONS 1-8



MEASURED SECTIONS 9-14

THE UNIVERSITY OF TEXAS
BUREAU OF ECONOMIC GEOLOGY
PETER T. FLAWN, DIRECTOR

SECTION 15
MOFFAT SECTION
BELL COUNTY, TEXAS

EDWARDS FORMATION — MOFFAT MOUND; COMANCHE PEAK FM. (THICKNESS IN FEET: 0, 50, 100, 150)

SAMPLE NUMBER	UNIT	FEET	DESCRIPTION
	17	16.4	Covered; float indicates Edwards lithology.
M-34, M-33, M-32, M-31	16	16.6	Fossiliferous pelsparite; contains Toucasia sp., caprinids, Chondrodonta sp., and mollusc fragments; Eoradiolites sp. occur at the top.
M-30, M-29	15	10.9	Fossiliferous oosparite grading upward into oolitic, biosparite and shell-fragment biosparite; contains caprinids, Chondrodonta sp., clams, Toucasia sp., oyster and mollusc fragments.
M-28, M-27, M-26	14	9.9	Fossiliferous oosparite; contains gastropods, clams and mollusc fragments; progressive increase in fossil content from base to top; some festoon(?) cross-bedding developed in the middle of the unit.
M-25, M-24, M-23, M-22	13	16.1	Fossiliferous oosparite; contains large mollusc fragments; poorly sorted.
M-21, M-20	12	9.5	Shell-fragment biosparite; contains very large mollusc and oyster fragments, probably rudistid; "herringbone" cross-bedding.
M-19, M-18	11	9.5	Fossiliferous oosparite; with miliolids and mollusc fragments.
M-17	10	3.5	Recrystallized.
M-16, M-15, M-14, M-13, M-12	9	20.8	Fossiliferous oosparite at the base, grading up into intraclastic, fossiliferous oosparite; with mollusc fragments and miliolids; intraclasts contain oolites; better sorted toward the top.
M-11	8	11.0	Recrystallized; weathers in a "honeycomb" manner.
M-10, M-9, M-8	7	9.4	Pellet, shell-fragment biosparite; contains Eoradiolites sp., caprinids, D. walnutensis, miliolids, algae and mollusc shell-fragments.
M-7	6	3.0	Fossiliferous intrasparudite; contains Eoradiolites sp., caprinids, miliolids, D. walnutensis, algae and mollusc fragments.
M-6	5	3.5	Fossiliferous pelsparite; contains gastropods, clams, D. walnutensis, algae, miliolids, echinoid spines and mollusc fragments.
M-5	4	7.7	Shell-fragment biomicrite; contains gastropods, clams, algae, mollusc and oyster fragments.
M-4, M-3	3	9.1	Intraclastic, algal, shell-fragment biomicrite to biosparite; contains G. mucronata, clams, gastropods, Dictyoconus walnutensis, algae miliolids, oyster and mollusc fragments.
M-2	2	4.5	Intraclastic, algal, shell-fragment biomicrite; contains Gryphaea mucronata, gastropods, clams, miliolids, echinoid fragments, algae, mollusc and oyster fragments; intraclasts are brown.
M-1	1	12.1	Shell-fragment biomicrite to fossiliferous micrite; contains gastropods, clams, miliolids, algae and mollusc fragments.

SECTION 16
LEON RIVER SECTION
BELL COUNTY, TEXAS

GEORGETOWN FM.; EDWARDS FM.; COMANCHE PEAK FORMATION (THICKNESS IN FEET: 0, 50, 100)

SAMPLE NUMBER	UNIT	FEET	DESCRIPTION
	10	5.0	Shell-fragment biomicrite; contains mollusc fragments and Pervinquieria sp.
LR-14	9	2.0	Miliolid biosparite; contains miliolids and mollusc fragments; may contain either pellets or intraclasts.
	8	3.7	Covered.
LR-13, LR-12, LR-11, LR-10	7	29.8	Rudistid shell-fragment biomicrite to biosparite; contains Eoradiolites sp., caprinids, Chondrodonta sp. and abundant rudistid fragments.
LR-9, LR-8, LR-7	6	23.3	Alternating, recrystallized micrite and clayey micrite (marl); contains scattered G. mucronata, gastropods, clams and mollusc fragments; has black chert nodules toward the base.
	5	47.0	Covered.
LR-6, LR-5	4	10.0	Recrystallized, shell-fragment biomicrite to fossiliferous micrite; contains G. mucronata, echinoids, miliolids, oyster and mollusc fragments.
LR-4	3	3.2	Shell-fragment, algal biomicrite; contains miliolids, algae, echinoid spines, mollusc and oyster fragments.
LR-3C, LR-3B, LR-3A	2	4.8	Fossiliferous intramicrudite to oolitic, shell-fragment biosparite; contains E. texana, Cladophyllia sp., miliolids, algae, mollusc and oyster fragments; composition very variable.
LR-2, LR-1	1	12.8	Shell-fragment biomicrite grading up into fossiliferous micrite; contains Exogyra texana, Gryphaea mucronata, gastropods, clams, echinoids, miliolids and mollusc fragments; scattered algae occur toward the top.

SECTION 17
COPPERAS COVE SECTION
CORYELL COUNTY, TEXAS

WALNUT FORMATION: KEYS VALLEY MARL MEMBER; CEDAR PARK LS. MEMBER; BEE CAVE MARL MEMBER; BULL CK. LS. MBR.; PALUXY FM.; GLEN ROSE FM. (THICKNESS IN FEET: 0, 50, 100)

UNIT	FEET	DESCRIPTION
13	8.7	Gryphaea biomicrite; consists of 75-80% G. mucronata, mostly whole and 25-20% clay and micrite matrix; has several very thin clay seams.
12	3.2	Shell-fragment biomicrite with a brown, Gryphaea shell-fragment biomicrite flag at the base; with G. mucronata, clams, gastropods and mollusc fragments.
11	32.4	Covered marl or clay slope; becomes harder toward the top and contains Oxytropidoceras sp., gastropods, clams and echinoids.
10	7.8	Fossiliferous micrite; with scattered G. mucronata, oyster and mollusc shell fragments.
9	4.3	Gryphaea shell-fragment biomicrite; contains whole and fragmented G. mucronata and mollusc shell fragments.
8	3.4	Brown, fossiliferous, calcareous clay with a single red, rippled Gryphaea shell-fragment biomicrite flag in the center; clay contains very large E. texana and small G. mucronata.
7	17.7	Fossiliferous micrite; with G. mucronata, mollusc shell fragments and occasional horn corals; becomes more fossiliferous toward the top.
6	20.2	Fossiliferous, brown calcareous clay with interbedded, hard, rippled flags of Gryphaea shell-fragment biomicrite; clay contains large E. texana and mollusc shell fragments.
5	3.4	Gryphaea shell-fragment biomicrite; made of a hash of whole and G. mucronata fragments with approximately 20% micrite matrix; also contains abundant mollusc fragments.
4	10.5	Shell-fragment biomicrite; with E. texana, clams, gastropods and mollusc fragments; Gryphaea mucronata toward the top.
3	4.4	Sandy, shell-fragment biomicrite; with Exogyra texana, clams, gastropods and mollusc fragments; quartz sand grains make up 5% of the rock.
2	6.6	Calcareous, fossiliferous, fine to very fine quartz sand; with thin clay laminae and shell fragments.
1	2.5	Recrystallized; structure obliterated; top surface looks bored.

SECTION 18
GRAY AIR FORCE BASE SECTION
CORYELL–LAMPASAS COUNTIES, TEXAS

EDWARDS FM.; COMANCHE PEAK FORMATION; WALNUT FORMATION: UPPER MARL MEMBER; KEYS VALLEY MARL MEMBER; CEDAR PARK LS. MEMBER; BEE CAVE MARL MEMBER; BULL CREEK LS. MBR.; GLEN ROSE FM. (THICKNESS IN FEET: 0, 50, 100, 150, 200)

SAMPLE NUMBER	UNIT	FEET	DESCRIPTION
GAB II-13	21	5.0	Recrystallized; contains caprinids and Eoradiolites sp.; forms distinctive bench throughout the area; locally quarried for road metal.
GAB II-12	20	11.0	Recrystallized; appears to be solution zone; contains caprinids and Eoradiolites sp.
GAB II-11	19	10.5	Recrystallized micrite(?); contains scattered clams and gastropods.
	18	33.5	Covered, unbroken, nodular(?) micrite slope.
GAB II-10	17	16.2	Fossiliferous micrite; contains scattered clams, gastropods, miliolids, and algae(?).
GAB II-9	16	12.6	Fossiliferous clayey biomicrite (marl) with a single bed of micrite which contains scattered mollusc fragments and algae; marl contains E. texana, gastropods and clams.
GAB II-8	15	19.0	Fossiliferous micrite; contains clams, gastropods, mollusc fragments and algae.
	14	13.5	Covered marl slope.
GAB II-7	13	1.2	Shell-fragment biomicrite; contains mollusc fragments.
	12	14.0	Interbedded clayey fossiliferous biomicrite (marl) and Gryphaea biomicrite; marl contains E. texana, G. mucronata, clams and gastropods; Gryphaea biomicrite is composed entirely of whole and fragmented G. mucronata in a micrite matrix.
GAB II-6, GAB II-IPA+IP	11	8.5	Shell-fragment biomicrite; contains G. mucronata, E. texana, clams, gastropods, Oxytropidoceras sp., echinoid and mollusc fragments; has 0.4 foot of G. mucronata biomicrite at the top.
	10	16.5	Caliche; structure obliterated.
GAB-5	9	5.4	Fossiliferous micrite; contains scattered G. mucronata, algae, echinoid plates, oyster and mollusc fragments.
GAB II-4	8	3.9	Algal biomicrite; contains scattered E. texana and G. mucronata, abundant algae, echinoid plates, oyster and mollusc fragments.
GAB II-3	7	2.4	Shell-fragment biomicrite; contains E. texana, G. mucronata, algae, mollusc and oyster fragments.
GAB II-2, GAB II-1	6	7.0	Clayey biomicrite (marl) with cross-bedded fossiliferous intrasparite flags; marl contains E. texana, G. mucronata and clams; flags contain algae, mollusc and oyster fragments.
	5	22.5	Covered, steep slope; nodular fossiliferous micrite float.
	4	15.8	Covered marl slope; float consists of pieces of ripple-marked, shell-fragment biomicrite flags.
GAB I-8, GAB I-7, GAB I-6	3	4.0	Gryphaea biomicrite; consists entirely of whole and fragmented G. mucronata in a micrite matrix; has thin fossiliferous clay seams.
GAB I-PM	2	5.4	Clayey biomicrite (marl); contains abundant E. texana, small Gryphaea mucronata, clams and gastropods.
GAB I-5, GAB I-4, GAB I-3, GAB I-2, GAB I-1	1	12.9	Sandy, intraclastic shell-fragment biomicrite; contains Exogyra texana, clams, gastropods, mollusc and oyster fragments, algae and miliolids; one bed 8.5 feet above base is shell-fragment biosparite; thin laminated clay at base may be Paluxy.

SECTION 19
TAYLOR MOUNTAIN SECTION
LAMPASAS COUNTY, TEXAS

WALNUT FORMATION: KEYS VALLEY MARL MEMBER; CEDAR PARK LS. MBR.; BEE CAVE MARL MBR.; BULL CK. LS. MBR.; PALUXY FM.; GLEN ROSE FM. (THICKNESS IN FEET: 0, 50, 100)

SAMPLE NUMBER	UNIT	FEET	DESCRIPTION
	14	6.5	Gryphaea biomicrite; composed of whole and fragmented G. mucronata in a marl matrix; 112.3 feet covered interval to the base of the Edwards.
	13	7.0	Alternating fossiliferous clay and hard shell-fragment biomicrite; clay contains E. texana, G. mucronata and Oxytropidoceras sp.; biomicrite contains G. mucronata, oyster and mollusc fragments.
TM-11, TM-10	12	3.5	Fossiliferous micrite; contains E. texana, Oxytropidoceras sp., clams, oyster and mollusc fragments.
	11	21.0	Covered marl slope with 1.0-foot bed of Gryphaea shell-fragment biomicrite at the base; float contains numerous G. mucronata at the base and Oxytropidoceras sp., clams, oyster and mollusc fragments.
TM-9, TM-8	10	9.8	Fossiliferous micrite; contains clams, miliolids, mollusc and oyster fragments.
TM-7, TM-6	9	7.5	Intraclastic shell-fragment biomicrite with clay and a ripple-marked flag at the base; clay contains scattered E. texana; ripple-marked flag composed of G. mucronata and mollusc fragments; top contains algae, mollusc and oyster shell fragments; intraclasts are red.
	8	21.6	Poorly exposed, fossiliferous micrite; contains mollusc shell fragments.
	7	16.2	Mostly covered; clay or marl with interbedded rippled shell-fragment biomicrite flags.
	6	4.2	Gryphaea shell-fragment biomicrite; contains Gryphaea mucronata and mollusc shell fragments.
	5	8.5	Covered marl slope.
TM-5, TM-4	4	4.9	Sandy, shell-fragment biomicrite; contains Exogyra texana, gastropods, oyster and mollusc fragments; contains large bored calcareous fine quartz sandstone pebbles at base.
TM-3	3	5.9	Very fine quartz sand; unconsolidated, not as well sorted as unit 2.
TM-2	2	2.5	Very fine quartz sand; unconsolidated, very well sorted, variegated maroon and gray.
TM-1	1	1.0	Recrystallized; contain miliolids and mollusc shell fragments.

SECTION 20
BACHELOR PEAK SECTION
BURNET COUNTY, TEXAS

COMANCHE PEAK FM.; WALNUT FORMATION: KEYS VALLEY MARL MEMBER; CEDAR PARK LS. MBR.; BEE CAVE MARL MBR.; PALUXY FM.; GLEN ROSE FM. (THICKNESS IN FEET: 0, 50, 100, 150)

SAMPLE NUMBER	UNIT	FEET	DESCRIPTION
	17	33.3	Fossiliferous micrite; with scattered clams, gastropods, mollusc fragments and occasional algae; U. S. G. S. bench mark "Bachelor", 1943 located at top of section.
BP-11	16	7.1	Fossiliferous micrite; with G. mucronata, E. texana, clams, gastropods and mollusc fragments; concentration of iron-stained G. mucronata occurs at top.
	15	5.0	Covered marl slope; many echinoids and E. texana on slope.
	14	4.1	Shell-fragment biomicrite; with G. mucronata, E. texana, clams and gastropods and mollusc fragments.
	13	9.9	Gryphaea biomicrite; with numerous whole and fragmented G. mucronata in a clay and micrite matrix.
BP-10	12	4.7	Shell-fragment biomicrite; with G. mucronata, E. texana, Oxytropidoceras sp., solitary corals, clams, gastropods, algae, mollusc and oyster fragments.
BP-TP	11	6.1	Clayey biomicrite (marl); with Oxytropidoceras sp., E. texana, gastropods, clams and shell fragments.
BP-9, BP-8	10	25.2	Clayey, Gryphaea biomicrite (marl) with interbedded, hard Gryphaea biomicrite ledges; slope covered with G. mucronata, making up at least 50% of the rock; bottom ledge contains 2-5% intraclasts.
BP-7	9	14.2	Fossiliferous micrite; with mollusc fragments, occasional G. mucronata and algae.
	8	4.0	Shell-fragment biomicrite; with abundant G. mucronata and mollusc fragments.
	7	2.8	Fossiliferous micrite; with G. mucronata, mollusc fragments and scattered miliolids.
BP-6	6	2.2	Intraclastic, shell-fragment biomicrite; with abundant G. mucronata, gastropods, clams, mollusc and oyster fragments, algae and miliolids.
BP-5	5	9.5	Fossiliferous micrite grading upward into shell-fragment biomicrite; with G. mucronata, mollusc and oyster fragments and algae; G. mucronata more abundant toward the top.
BP-4, BP-3	4	20.1	Brown fossiliferous clay with interbedded hard, shell-fragment biomicrite flags; with E. texana, mollusc and oyster fragments; last flag is fossiliferous intramicrite; with G. mucronata, oyster and mollusc fragments.
BP-2	3	1.0	Fossiliferous intrasparite to intramicrite; with mollusc and oyster fragments and algae, intraclasts are brown.
	2	6.3	Clayey, shell-fragment biomicrite (marl); with abundant Exogyra texana, Gryphaea mucronata, clams and mollusc fragments.
BP-1		.5	Calcareous, quartz-dolomite fine sandstone; rounded and angular dolomite grains occur in the laminae of cross-beds; with scattered, very fine oyster fragments.
		6.0	Fine-grained quartz sand; with cross-beds dipping 12° SE.

SECTION 31
OWL CREEK SECTION
CORYELL COUNTY, TEXAS

EDWARDS FM.; COMANCHE PEAK FORMATION; WALNUT FORMATION: UPPER MARL MEMBER; KEYS VALLEY MARL MBR. (THICKNESS IN FEET: 0, 50, 100)

UNIT	FEET	DESCRIPTION
8	10.0	Recrystallized; no structure or allochems preserved.
7	3.0	Fossiliferous pelsparite to oosparite; contains mollusc fragments.
6	70.0	Fossiliferous micrite to shell-fragment biomicrite; contains E. texana, G. mucronata, clams, mollusc fragments and echinoids.
5	11.8	Clayey biomicrite; contains G. mucronata, E. texana, and echinoids; distinctive color change at lower contact from white below to rust brown above; top marked by hard, brown, shell-fragment biomicrite flag.
4	25.6	Alternating fossiliferous micrite and clayey biomicrite; contains G. mucronata, E. texana, clams and mollusc fragments.
3	13.5	Alternating hard, shell-fragment biomicrite flags and clayey biomicrite; contains G. mucronata and mollusc fragments.
2	10.0	Gryphaea biomicrite; composed almost entirely of G. mucronata in 10-15% micrite matrix.
1	1.0	Clayey biomicrite; contains numerous Oxytropidoceras sp.

SECTION 32
KEYS VALLEY SECTION
BELL COUNTY, TEXAS
(TYPE SECTION)

WALNUT FORMATION: UPPER MARL MBR.; KEYS VALLEY MARL MBR.; CEDAR PARK LS. MBR. (THICKNESS IN FEET: 0, 40)

UNIT	FEET	DESCRIPTION
6	4.0	Calichified, clayey biomicrite; mostly covered.
5	5.0	Gryphaea biomicrite; composed almost entirely of whole and fragmented G. mucronata in 10-15% micrite matrix.
4	5.4	Shell-fragment biomicrite to fossiliferous micrite; contains scattered mollusc and oyster fragments.
3	16.2	Clayey, shell-fragment biomicrite; with hard Gryphaea biomicrite flags and one brown siltstone bed toward the top; contains E. texana, G. mucronata, clams, gastropods, mollusc fragments and a concentration of Oxytropidoceras sp. toward the top.
2	4.0	Shell-fragment biomicrite; contains Exogyra texana, Gryphaea mucronata, gastropods, clams and mollusc fragments; has bored fossiliferous pebbles at the base.
	5.0	Fossiliferous micrite; contains algae, solitary corals and mollusc fragments.

SYMBOLS USED ON MEASURED SECTIONS

A. LITHOLOGIC

- Nodular limestone
- Cross-bedding
- Bored surface
- Nodular limestone with burrows
- Chert nodules
- Bored limestone pebbles
- Recrystallized
- Shell fragments
- Pellets or Oolites

B. PALEONTOLOGIC

- Gryphaea sp.
- Exogyra sp.
- Oyster
- Echinoid
- Gastropod
- Clam
- Ammonite
- Dictyoconus walnutensis
- Coral
- Eoradiolites sp.
- Caprinid
- Toucasia sp.

C. GENERAL

NSGI - 1	Lithic sample number
NSGI - 1P	Paleontologic sample number

Note: Locations shown on figure 12 for sections 15, 16, 31, and 32; on figure 11, for sections 17-20.

MEASURED SECTIONS 15-20, 31, AND 32 (TYPE SECTION)